Central

SCIENTIFIC AMERICAN
SUPPLEMENT



VOLUME LXXV ]
NUMBER 1938 ]

NEW YORK, FEBRUARY 22, 1913

[10 CENTS A COPY
[$5.00 A YEAR

# The Heavy-Oil Engine in Marine Service

## Its Influence Upon Battleship Design

### By R. Clifford H. Reid

Since about 1906 or 1907 the naval world has been astir at the advent of the all-big-gun ship of the dreadnought type. Beneath the surface of this excitement, in the sphere of guns and armor, there has been a steady and rapid evolution of the main propelling machinery of ships, resulting in the struggle between the steam reciprocating and turbine engines.

Just now we are witnessing the rise of the oil engine, whose coming appears fraught with great possibilities. In the recent Naval Number of the Scientific American, Rear-Admiral Hutch I. Cone says in part: "It now seems probable that none of the methods of propelling medium-speed naval vessels, which are forms of steam machinery, will endure. This in consequence of the remarkable development of the heavy-oil engines of the Diesel type in Europe."

Many writers have, however, strongly urged objections to the adoption of the oil engine. The force of these arguments, in the light of latter day developments, seems to be largely temporary as already the solution of many of the problems involved is being accomplished.

In the sequence of Admiral Cone's statement, it is the arguments relative to the application of this engine in "medium-speed naval vessels," notably the battleship, which are of greatest concern.

1. It is contended that there exists a lack of experience in the application, on a large scale, of oil engines in marine practice. This argument is wholly temporary as that experience is soon to be acquired both in the naval and mercantile professions.

2. The steaming qualities of the "Oregon" during the Spanish War, the work of the British cruisers "Powerful" and "Terrible," with the "remarkable" showing of the Chilian "Chacabuco," which after seven years of service was still able to exceed her contract speed by three quarters of a knot; these and many like performances have created a strong prejudice in favor of the steam engine. The consistent work of those oil engines now in use will ultimately cause a change of sentiment. It is only necessary to recall the criticisms of old sailors on the advent of the steam engine to find a parallel case.

3. There are also mechanical features which are giving trouble. One of these is met in casting large cylinder units, another in the great temperature rise of the engine, with consequent necessity of cooling. Heat troubles have already been encountered in the use of superheated steam and experience gained there will assist materially in attacking this greater problem.

The result of the above has been the limitation of single engine units to about 3,000 horse-power output. Eight or ten such would be required for a dreadnought. This contingency is being met, for already a 12,000 horse-power equipment is being built by one of Germany's foremost Diesel engine builders.

4. Oil engines are more costly than corresponding steam equipment. Therefore, unless they wear as well this will be an important factor, and one which time alone can test.

5. The dangers of handling oil have been very strongly set forth by writers. The extensive use of it in the larger battleships of the great naval powers as an adjunct to coal, together with its exclusive use in modern destroyers as well as our newest battleships, may be considered to have closed this issue.

6. Fuel oil is not common in most countries, being about twice as costly in Europe as at San Francisco. The United States is in a particularly favorable position, "producing, as we do, two thirds of the world's supply." England is much pleased with the newly discovered shale-oil fields of Scotland. She is now constructing a chain of oil-supply depots on the route to the far East. Experiment has proven also that fish oils, tar oils, and vegetable oils give satisfaction in Diesel engines.

7. At present the coal bunkers of a warship are an important item in its protection. But the weight saved in the use of oil, even in steam-engined ships, permits a more than proportionate thickening of armor plates.

8. It has been contended that the introduction of oil engines would be superfluous, as a man-of-war requires steam anyway for the operation of winches, turrets, and other auxiliary machinery. The day of hydraulic or steam machinery for such auxiliaries is passing, even in the British navy. The long and satisfactory use of electricity has contributed no little to the terrific, fast, hard-hiting qualities of our battleships which we proudly acclaim to be the superiors of any afloat.

But would we not indeed gain an additional advantage in the introduction of a type of engine well fitted in itself to serve as a reserve, available upon the disablement or failure of the electrical equipment; a most important point in warship design?

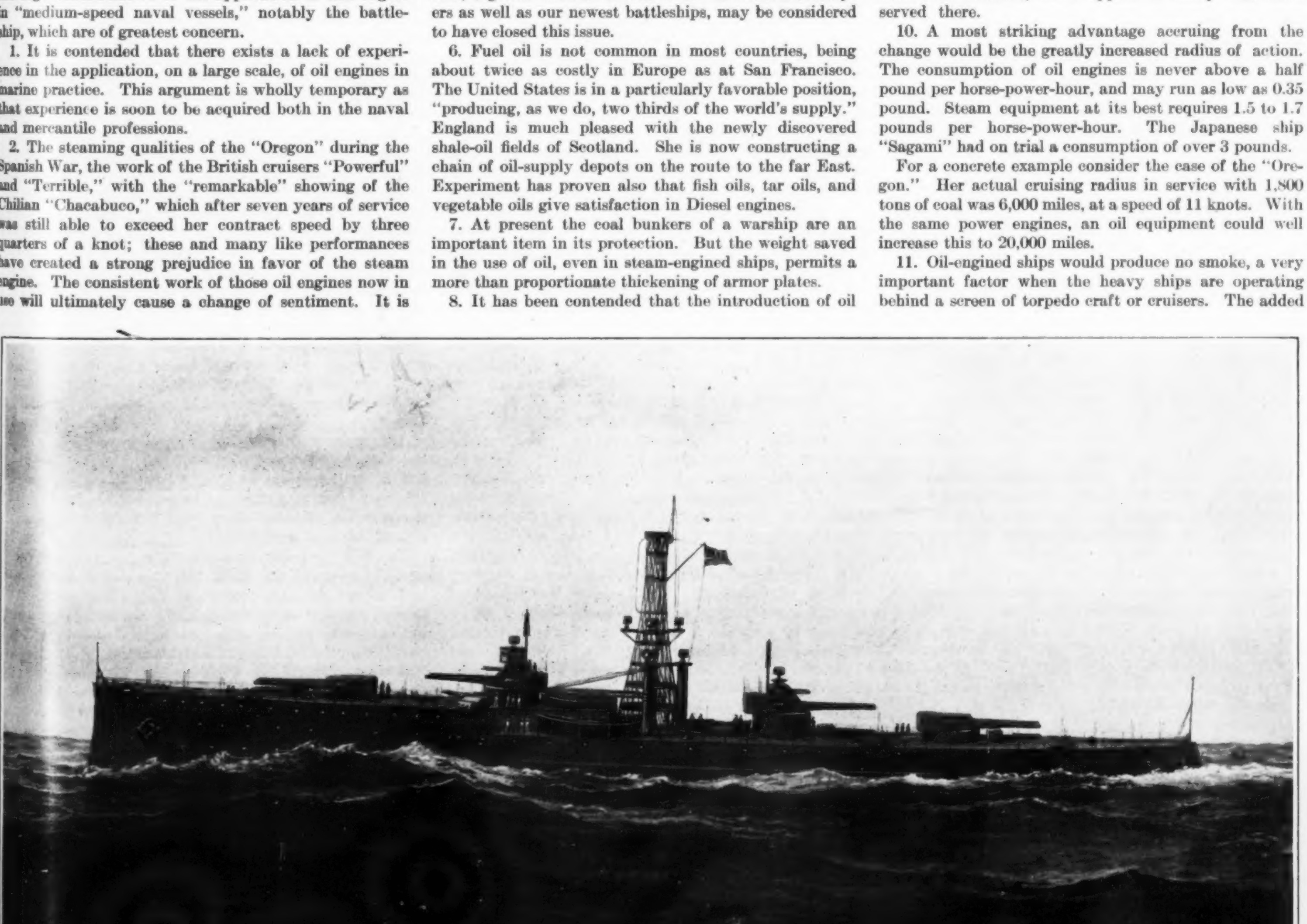
Having disposed of the previous objections, it is well to consider what advantages may be derived by the introduction of this new motive power. Also wherein it may serve to make possible an increase in the efficiency of future battleship design.

9. The oil engine does away with boiler space and weight. The weight saved may well be given to increasing the offensive and defensive qualities of the vessel. The elimination of fire-room crews, with attendant stoke-hole troubles, must appeal to many who have served there.

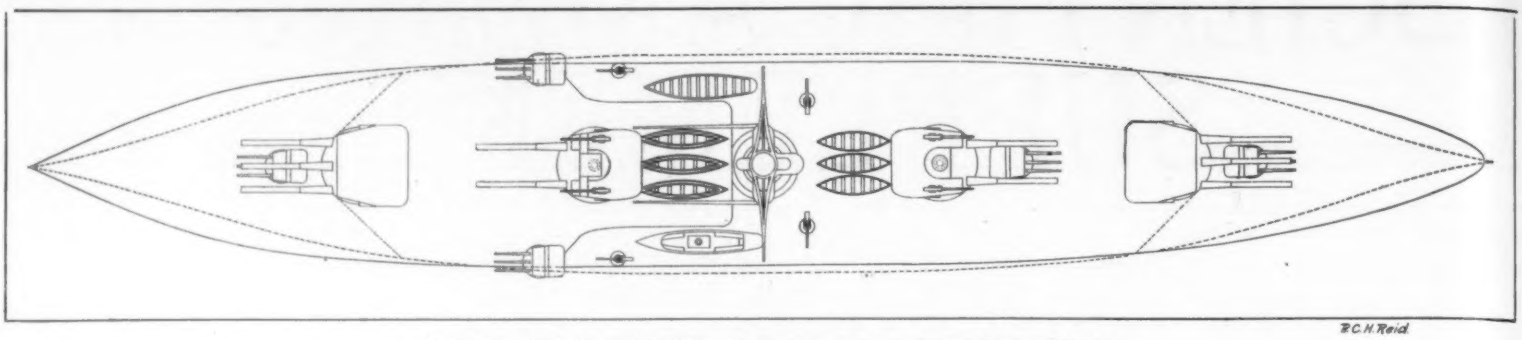
10. A most striking advantage accruing from the change would be the greatly increased radius of action. The consumption of oil engines is never above a half pound per horse-power-hour, and may run as low as 0.35 pound. Steam equipment at its best requires 1.5 to 1.7 pounds per horse-power-hour. The Japanese ship "Sagami" had on trial a consumption of over 3 pounds.

For a concrete example consider the case of the "Oregon." Her actual cruising radius in service with 1,800 tons of coal was 6,000 miles, at a speed of 11 knots. With the same power engines, an oil equipment could well increase this to 20,000 miles.

11. Oil-engined ships would produce no smoke, a very important factor when the heavy ships are operating behind a screen of torpedo craft or cruisers. The added



**The Use of the Heavy-oil Diesel Engine Renders Possible Heavy Concentrated Protection, Great All-round Fire, and Symmetrical Distribution of Weight.**




Plan View Showing Disposition of Armament on a Diesel Engine Warship.

advantage of clear vision when fighting an action to leeward is readily recognized.

12. Of the greatest importance would be the abolition of the huge smokestack itself. The peril of a shell exploded in the stack, hurling its fragments down the uptakes, thus cutting boiler tubes and scalding firemen, has for long been a much talked of danger. Generally it is agreed that in this way alone could an aeroplane do material damage to a modern dreadnought.

Most striking is the actual case of the Russian battleship "Tsarvitch," in the battle of Round Island. Her smoke stacks were badly torn by exploding shells, with the result that the coal consumption was increased six-fold, compelling the crew to intern a powerful unit, otherwise possessing splendid fighting qualities, in a Chinese port, where she was of as little use to the Russians as if on the planet Mars.

That this incident commanded earnest thought and consideration is shown by the armor, most pronounced in the Oklahoma class, now protecting the base of the stacks in our dreadnoughts. But such armoring has only lessened the degree of weakness, while making the elimination of the stack more desirable.

13. When doing station, as in blockades, fleets are often steaming at much reduced speed. At such times coal economy limits the number of boilers in use. Under these conditions it requires time to break fires necessary to getting under full headway, which delay may be of great advantage to the enemy. In an oil-engined ship, on the other hand, full power is almost instantaneously available, thus greatly increasing the mobility.

14. The absence of the "Massachusetts" from the battle line at Santiago illustrates what coaling means in the presence of the enemy. The use of oil should make the operation of taking on fuel much safer in open waters.

15. From the military standpoint the abolition of smokestacks, uptakes, boilers, etc., would give a much greater arc of train for the big guns by permitting a better disposition of the turrets. Moreover the increasing power of torpedo craft may make the greater deck space available for all secondary guns of paramount importance.

16. Following closely the line of this argument, a greater isolation of the magazines and vital parts of the ship would be possible, together with a more complete subdivision of the hull.

17. Such concentration of the propelling machinery would make practicable a system of under-water armoring, against torpedo attacks, similar to that embodied in the "Henry IV" of the French navy.

18. Oil can be easily stowed in the double bottom of the ship. Thus at once is obviated that difficulty in reaching the coal, so noticeable in the Japanese "Soya," yet appearing to a lesser degree in many ships.

The accompanying illustrations clearly show the possibilities of heavy concentrated protection, great all-round fire and symmetrical distribution of weights resulting from the use of the heavy-oil Diesel engine. It must not be expected that our next warships will be so equipped, but rather that, at a time not far distant, these great possibilities may be realized.

# Conservation and Research*

## Economies Secured by Scientific Investigation

### By Herbert T. Kalmus

We are all impressed in these times with the increasing importance of our problems of conservation, and we regard with extreme pleasure the active and vigorous steps which the various governments have taken, and are taking, to insure that there be a minimum of waste in obtaining our raw materials. To most persons conservation means to draw upon nature for our supply of the various natural products that we require, in such a manner that posterity may not complain that we have been unduly wasteful or extravagant. The fundamental importance of this kind of conservation is very generally recognized, and I shall dwell upon it only in passing, but there is another type of conservation, less recognized, but equally important, of which I wish particularly to speak. This is the conservation resulting from scientific investigation and research.

On this continent we have acquired the habit of being well satisfied with what we have accomplished. We marvel at our enterprise in scraping iron ore from the earth's surface by steam shovels and in growing wheat and cotton on virgin soil, in stripping great areas of primeval forest and in allowing petroleum to spout from the ground. We cut more ice along a few hundred miles of our northeastern shore in one month than all the Pictet machines in France can turn out in a year, and we control the copper and nickel markets of the world because nature has given us copper and nickel. If you want cheap sulphur you must come to us, for we pump it from the ground, and we develop great centers of power distribution because our rivers run so rapidly down hill. To these vast resources we have applied a native energy and genius, in certain respects probably unequalled by any other people, but nevertheless, what we do on this great scale we often do wastefully and extravagantly. Is it not time for us to pause in our progress to inquire whether things might not be better done, whether indeed the more conservative methods of other nations, given equal opportunity, might not put our own performance to shame?

Most of the materials extracted from the earth have been exploited for thousands of years. However, the drafts upon the reserves of the earth as compared with its total capacity were small until the beginning of the nineteenth century. From the dawn of civilization until that time, the amounts of minerals and metals mined had been so inconsiderable that it was thought that they would last through the indefinite future. Toward the latter half of the nineteenth century began the age of scientific advance and invention and of industrial and commercial operation on a large scale. Forecasts of the life of mineral resources made prior to that time became worthless in view of the tremendous acceleration at hand. Indeed, on this continent the output of the all important products, coal and iron, has approximately doubled in ten years, or looking back further, the output of the first decade of this century has been more than that of all previous decades.

In his presidential address before the British Association for the Advancement of Science, Sir William Ramsay stated that if the present increase in the output of coal mines in the British Isles continued, the supply would be exhausted in 175 years, a very brief space in the life of a nation. More recently the time has been extended, owing to the discovery of new coal areas, but it is by no means unlimited. On this continent the coal supply is more nearly unlimited, but even here, if we take into account the increasing uses for it, and if we have in mind coal which can as readily be mined as is the case at present, we can hardly contemplate the future without concern. In the year 1910 there were mined about 1,300,000,000 tons of coal. Of this, over 40 per cent was produced on this continent, and yet, according to Dr. J. A. Holmes, Director of the U. S. Bureau of Mines, more than 2,000,000,000 tons of anthracite coal and more than 3,000,000,000 tons of bituminous coal have been left underground in such condition as to make their future recovery doubtful or impossible. That there is tremendous waste in the mining of fuel supplies in North America is generally recognized, but its magnitude is beyond comprehension. In the mining of coal probably not 50 per cent of it is removed from the ground and brought into a form such that it can be economically utilized.

It is with this type of conservation, that of reducing waste in connection with reaping the various harvests of nature, that the governmental commissions have had primarily to do. We are glad that the work is being so well done, and that we are being so abundantly informed of it through the various governmental publications. However, this is but one aspect of conservation. It is not sufficient that we cut our timbers with as little waste as possible, and in such a manner that they may grow again; it is not enough that we legislate against removing that portion of the coal which is most easily removed, which yields immediate high financial return but which leaves a large fraction buried for all time; it is not enough that we devote ourselves solely to the economy of production of raw materials, once they are at hand. Economical production and efficient utilization are in series as are two links of a chain, they are equally important. Surely it must be appreciated that the more efficient utilization of any material must react to cause us to draw upon nature to a lesser extent for that particular product, and hence, quite as truly as diminishing wastes in the first production of the material, it effects a real conservation.

These latter conservations are usually brought about, directly or indirectly, as the result of painstaking experimental investigations of scientific men, engineers, physicists, chemists, metallurgists, etc., in their various laboratories and practices. Without attempting to select the most important of these, even of those of very recent date, let me illustrate with a few typical instances.

Consider the chemist at work in his laboratory studying the solubility of boiler scale. It is estimated that boiler scale in the locomotives of this continent alone causes an annual loss of over 16,000,000 tons of coal. One sixteenth of an inch of boiler scale means a loss of 13 per cent in efficiency, and one eighth of an inch of boiler scale, which occurs in many boilers, means a loss of 25 per cent in efficiency. Thanks to the work of the research chemist, the deposition of these scales has been reduced and reduced, until now they assume but a small fraction of their former significance. In this way, but so as not to be generally noticed, has the research chemist effected an important conservation of our coal supplies.

You will probably remember that not many years ago, the name of the metal tungsten was unknown to you. Even for the chemist it was a curiosity. At present not only are we familiar with the metal tungsten, but our homes and our offices are lighted with incandescent lamps, the filaments of which are fine drawn tungsten wires. Dr. W. R. Whitney and his associates at the Research Laboratories of the General Electric Company have studied this metal for several years, but it is only comparatively recently that they have succeeded in producing it in a state of ductility such that it could be properly drawn into fine wires. These tungsten lamps are a great improvement on the old carbon filament, for they radiate the same amount of light at about one half the cost, which, translated into terms of conservation, means that they have effected a direct wholesale saving of coal for all time.

It is interesting to note the way in which researches on tungsten have effected real conservations in other ways. This hitherto almost worthless element has been found, when properly formed, to have properties far superior to those of any known metal for the manufacture of X-ray tubes. In modern X-ray practice powerful electrical apparatus is used to excite the tube. The greater part of the energy delivered to the tube is transformed into heat at the point where the cathode rays bombard a metallic target. Where platinum is

* Reproduced from *Queen's Quarterly*, Toronto, Canada.

used, which melts at 1,780 deg. Cent., it has been found necessary, in order to prevent melting, to place the target beyond the focus of the cathode, so as to spread the bombardment over a larger area. Without going into detail, this means at best an X-ray picture with poor definition due to the danger of melting the platinum. Tungsten, with a melting point of 3,000 deg. Cent., permits of sharp focussing of the rays on the target and of the use of more energy through the tube, and consequently of a shorter exposure than has been hitherto possible. Aside from the direct value of this research to humanity, it will obviously substitute a new metal for the very limited and most costly one hitherto used, platinum, thus conserving the platinum for other uses where it alone can fulfill the requirements. The significance of this becomes obvious when we reflect that the demand for platinum and its relatively diminished production, has caused its price to soar from twenty dollars an ounce troy in 1908 to forty-eight dollars an ounce troy in 1912.

Ages ago there were stored up, chiefly by the influence of plant life, immense deposits of carbon and nitrogen, which have made modern civilization possible. Some of this nitrogen may have been compounded to its present useful form by electrical discharges in the atmosphere, but it is highly probable that the larger portion of it was formed of bacterial action. Certainly it appears to be true, that the 500,000,000 tons of sodium nitrate, which are known to be deposited in the desert of Atacama, Chili, are of organic origin, from plants and animals whose refuse, under peculiar conditions of heat and water supply, was oxidized and collected in this unique locality. Until recently, we have drawn from these deposits practically our total supply of the element nitrogen, which is absolutely essential for both plant and animal food. Besides, we have drawn from this source all of the nitrogen without which we could not have explosives, upon which depends the whole of our mining industry. Our waste of nitrate as fertilizer has so impressed the human mind that the daily press for years has pointed out the possible starvation of man because of the inability of the earth to supply nitrate for plant life. About two and one half million tons of sodium nitrate are being taken each year from Chili, a fact which means that the probable time of depletion of these deposits is less than a century away. Call it two centuries if you like, or five, the principle is the same. Yet, in the manufacture of coke for various industries during a recent period, but $3,800,000 worth of $160,000,000 worth of recoverable nitrogen, which the original coal contained, was saved. The balance went off into the air as free nitrogen. This nitrogen, among other things, has been saved by the Germans under similar conditions for a number of years, and is now being saved on this continent to a very rapidly increasing extent, as the result of the development of new metallurgical ovens and new chemical processes.

In comparatively recent years a vast amount of research has been carried on, principally in Germany, the outcome of which has been the development of the wonderful coal tar industry. This industry, which is probably the greatest single example of chemical progress, has as yet not been developed on this continent. It has effected conservations in many ways of which I shall recall but a single one. Among the valuable by-products of this industry are materials from which are prepared an endless variety of dyes and coloring substances. All the analine dyes are made from distillation products from coal. These formerly required rich land now devoted to other purposes. Indigo alone, now prepared from coal tar, is equivalent to over 300,000 acres of indigo plants.

To me there is no novel more interesting nor story of adventure more fascinating than accounts published during the last few months of the work of Prof. Haber, which has resulted in the preparation of the nitrogen compound ammonia directly from the nitrogen of the air. At first obtaining only microscopic quantities of his product, later finding that the process was poisoned by minute traces of impurities which it seemed impossible to remove, obliged to work at extremely high temperatures and at very great pressures, and beginning a study which had been given up as impossible by dozens of prominent scientists in the past, Prof. Haber and his research associates are now able to announce that the problem has been fully solved on a manufacturing scale and that the walls of their first factory for synthetic ammonia are already rising above ground. Henceforth man will be able to prepare fertilizers to enrich his soil directly from the atmosphere which everywhere surrounds him.

A number of thoughtful scientists are expressing the opinion that the future will be the age of iron and aluminium. These seem to be provided by nature in practically inexhaustible quantities, but our methods of working their ores to produce the pure metals introduce many extravagances. Even if these extravagances may be overlooked as regards the loss of the metals as such, they are extremely important in connection with conserving other materials necessary to the process. When we consider that the steel industry of this continent produces annually over twenty million tons of steel, we may appreciate what a very minor improvement might mean in the way of conservation. The modern trend in this industry has been to study the possibilities of producing pig iron and steel in electric furnaces. For certain grades of steel this is eminently successful, and although not finally demonstrated as yet for pig iron, the world is greatly indebted to the Canadian Bureau of Mines, under the direction of Dr. Eugene Haanel, for extensive researches on "Electrothermic Production of Pig Iron."

During recent years much painstaking research has been undertaken to control the hot acid smoke, laden with flue-dust and with vapors of poisonous sulphurous and arsenious compounds, which are discharged from the stacks of the various smelters. Several large copper smelters in the western part of the continent were forced by the Government to suspend operations, owing to the devastation of the surrounding country. A single smelter in California emitted more than one hundred thousand cubic feet of poisonous gas per minute. Prof. C. L. Parsons says that we discharge into the air through a single stack of the Washoe smelter as much sulphuric acid as is utilized throughout the whole continent. Considering that sulphuric acid is the basis of most of the important chemical industries and of the manufacture of fertilizers, the saving of this waste assumes an enormous importance. Very recently, as a result of a long painstaking research, several important processes have been and are being introduced at the smelters to save the useful products of these fumes. In this instance, however, as important as may be the saving of the materials, the really important conservation is that of the industry against its own self-destruction and of the valuable land which it was ravishing.

Only three years ago a leading scientific mind said: "The crest of our known resources of highest grade copper is already passed, and we are using lower and lower grades with increasing cost of production. The increasing inadequacy of our copper supply is a matter of deep concern." So rapid, however, has been the progress in the metallurgy of low grade copper, that it is now proving more profitable to work than was previously the case with the high grade ores. Indeed, although our production of copper has increased several hundred per cent in the last twenty-five years, and the annual output and consumption is still increasing, yet prices are lower than they were three years ago. This must be credited to the greater efficiency of metallurgical processes, making possible the utilization of deposits formerly supposed to be worthless.

Even this brief review of some of the important points at which the experimental investigator touches the problems of conservation would be incomplete without mention of the recent and present work on peat by the Mines Branch, Canadian Bureau of Mines. Peat is a material found in extensive bogs, in nearly every province of Canada. As removed from the bogs it is unsuited for use as fuel, but after special treatment, including drying and briquetting, it makes excellent fuel. Some idea of the extent to which the utilization of this peat fuel deposit would conserve other forms of fuel, wood and coal, may be obtained from a recent low estimate of the peat resources of Canada as "equivalent to nearly 16,000,000,000 tons of coal."

Many of these problems of conservation may best be studied by the individual producers most concerned, but certain of the most important of them are essentially public problems. These have either been unsuccessfully attacked or not studied at all by the manufacturers. Such studies can best be undertaken by the people's institutions, the Government bureaus or the universities, often best by the co-operation of the two. It is a matter of common knowledge that in the manufacture of brass about 8 per cent of the total zinc is lost as vapor. No individual brass manufacturer, enormous and wealthy as many of them are, has been interested to expend the money and the time necessary to overcome this difficulty. The people ultimately pay for this loss of zinc in the increased price of brass. During the past year the U. S. Government, co-operating through its Bureau of Mines with Cornell University, has undertaken an extensive investigation of this process. Our own Government is not behind in recognizing the importance of the work to be accomplished by co-operating with Canadian Universities, and we of Queen's University are glad to feel that she is playing so important a part in carrying out extensive investigations for the Dominion Government on the effective utilization of certain of our own important natural mineral resources.

These are but a few of the savings which the research man has enabled those operating the various industries to bring about in recent years. Sometimes this saving is due to the utilization of new elements to replace old ones which are becoming exhausted; often it is brought about by supplying an entirely new compound or mechanism. Of the fifty metallic elements now known, there were only seven in commercial use two thousand years ago, viz., zinc, iridium, platinum, cobalt, nickel, antimony, cadmium and bismuth. That is, the rate of addition has been less than one metal for each two centuries prior to our century. Within our time, that is, during the last twenty-five years, there have been about fourteen metals added to commercial use, or the addition has been at a rate more than one hundredfold the previous rate.

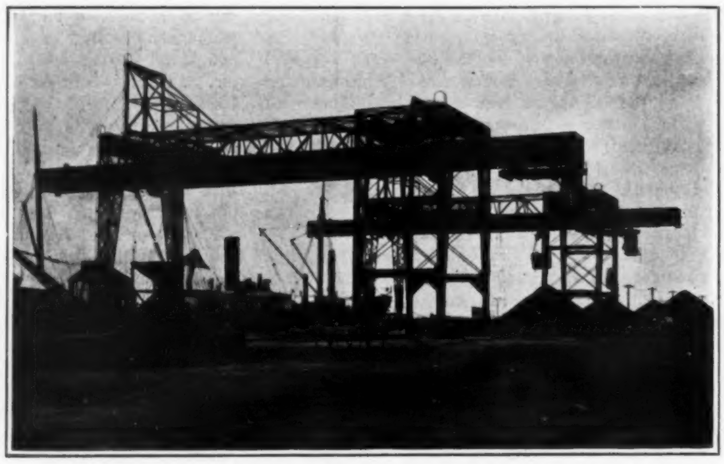
A notion of the rapidity with which research has brought about changes in the various electro-chemical and metallurgical industries, is well illustrated by the statement of the president of one of our largest chemical corporations, that "progress in chemical industries is taking place so rapidly through the study of new processes, introducing new machinery, new methods and new materials, that my company has very little in the way of plant to-day which was in existence ten years ago." Whether we are proud of it or not, this is an industrial century and we are industrial people. New discoveries in our day are largely mental instead of geographical, and the old battles of conquest have become wars with ignorance. We are constantly attempting to broaden our mental horizon as our ancestors broadened their physical horizon.

## The Refinements of Detection

In spite of the extreme delicacy of many scientific tests, notably those in which the services of the spectroscope and the electroscope are enlisted, the eye and the nose are capable, in regard at any rate to some substances, of an equal refinement of detection; they can detect quantities as inconceivably small. When we reflect, for example, how great is the tinctorial power of some of the modern aniline dyes, it must be obvious that in very great dilutions when the eye still observes color the quantity of material present must be quite microscopic. Comparatively recently there has been introduced a series of dyes which ousted the eosins; they are known as the rhodamines, and yield magnificent red shades. The dye classed as G extra continues to show distinct color obvious to the eye in a solution when there can be present only, and probably less than, one ten billionth of a gramme. This means that in a milligramme of solution there is present at least one particle of color substance weighing less than 0.000,000,000,000,1 gramme. The sense of smell is capable of detecting even smaller amounts of particles, for the presence of otto of roses in the air is readily recognized when only one third of a thousand billionth of a gramme (0.000,000,000,000,000,333 gramme) of the volatile oil is present in a cubic millimeter of air. It seems evident from this that the mere existence of an odor in the air can have very little chemical significance, and that any physiological effect it may produce (e. g., nausea) is a depressing one upon the nervous system, and not that of a toxic substance introduced into the blood stream. When the extremely minute quantites of substances which it is possible thus for the optic and olfactory nerves to detect are compared with the capabilities of, say, the spectroscope, it will be found that the human mechanism compares favorably with this instrument in regard to its powers of detection. The spectroscope is generally regarded with wonder because of the very minute quantities of substances which it will disclose. But when we find that in the case of neon it will detect the presence of 0.000,005 cubic centimeter, and in other examples 0.000,06 milligramme of strontium, 0.000,01 milligramme of lithium, and 0.000,000,3 milligramme of sodium, it will be seen that these quantities are gross compared with the detective powers of the human nerves. In, however, the scientific instrument used in electrical observations, the electroscope, the human agencies meet with a formidable competitor, for a delicate electroscope is nearly a million times more sensitive than a spectroscope. The modern instrument will detect one millionth of a millionth of a milligramme of radium. These refinements of detection suggest that they are capable of laying bare particles which are not matter at all, but energy; the infinitesimal is detected and weight, as we ordinarily know it, can scarcely enter into the calculation.

In this connection it is interesting to note the size of molecules. As B. J. Brown puts it in *School Science and Mathematics*, in one pound of water there are as many molecules as there would be packages, if the whole earth were divided up into parcels of one quarter of a pound a piece.—*The Lancet.*

View Taken from the Top of the Grain Elevator, Showing Warehouse in Course of Construction.



View Showing Two Traveling Bridge Cranes Discharging Coal from Steamers in the Harbor.

# An Ocean Terminal for the South

## Texas City Harbor Developments

By L. C. Talmage

At an expenditure of over $4,000,000 to date there is under construction at Texas City, the mainland port on Galveston Bay, what is conceded to be the most finely equipped and best constructed ocean terminal system south of New York. Steel and reinforced concrete have been used extensively in the construction of warehouses while labor-saving machinery have been installed to eliminate in a large measure hand labor in handling freight; and as a result there has been a reduction in insurance rates and a lowering of freight-handling expenses.

The first unit of the system consists of a pier 1,200 feet long and 1,000 feet wide upon which are located four warehouses, two traveling bridge cranes, and leads and sidings, and land terminals which include four warehouses, a reinforced concrete elevator, a central power plant, and some thirty-five miles of leads and sidings. With the exception of two wooden structures built in 1904, before the present fine system was undertaken, all warehouses are fireproof, minimizing fire risk and affording exceptionally low insurance rates. A number of these warehouses are equipped with labor-saving devices.

The second unit consists of a pier 900 feet long and 500 feet wide upon the north side of which is now in course of construction a double-deck reinforced concrete warehouse covering an area 155 by 880 feet. An inclined railroad will place cars on a level with the second floor. This warehouse will be duplicated on the north side of the pier and the intervening space will be occupied by tracks.

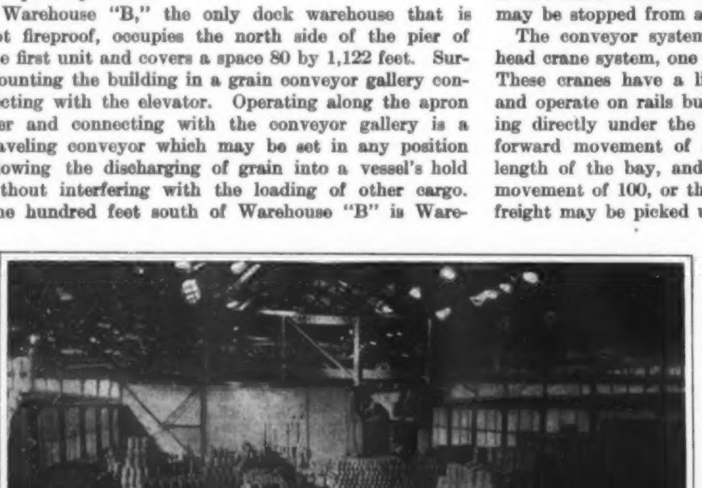
Warehouse "B," the only dock warehouse that is not fireproof, occupies the north side of the pier of the first unit and covers a space 80 by 1,122 feet. Surmounting the building in a grain conveyor gallery connecting with the elevator. Operating along the apron pier and connecting with the conveyor gallery is a traveling conveyor which may be set in any position allowing the discharging of grain into a vessel's hold without interfering with the loading of other cargo. One hundred feet south of Warehouse "B" is Warehouse "C," a steel and concrete warehouse covering an area 100 by 750 feet The foundations of this building are of concrete and the walls, supported by structural steel framework, are of cement plaster on metal lath. The roof is of concrete tile laid on steel framework. The warehouse is divided into three sections or bays by firewalls, the openings between the bays being protected by automatic fire doors. Extending through this warehouse is a Hanak system floor conveyor for the transfer of freight from shipside to any section of the building or, if desired, directly to cars. The system consists of four sections of 65½ feet each, driven by a duplex drivehead at every alternate section. There are six 6-horse-power motors along the straight line conveyor, or two to each bay of the warehouse. Every alternate section is equipped with a bascule section to permit the lowering of fire doors or free passage from bay to bay when the conveyor is not in use. At a maximum uniform load the conveyor will carry 220 tons of wire products or nails, the commodities handled exclusively in this warehouse. At the far end of the building there is a lateral conveyor 50 feet long which receives merchandise from the mainline conveyor and discharges directly into cars at either side of the warehouse. There are also four 12-foot portables which are used as laterals and can be placed at any point along the mainline conveyor for diverting freight to cars alongside the warehouse. The motors operating these conveyors are 230-volt direct current, compound wound, are connected to run in either direction and are wired to the main current in such manner that all motors may be stopped from any point along the system.

The conveyor system is supplemented by an overhead crane system, one crane in each of the three bays. These cranes have a lifting capacity of 2 tons each, and operate on rails built along the sides of the building directly under the cross beams of the roof. The forward movement of each crane is 250 feet, or the length of the bay, and the hoist carriage, has a side movement of 100, or the width of the building. Thus, freight may be picked up a' any point in the bay and transferred to any other point, piling in tiers to a height of 22 feet from the floor level. In handling barbed wire or rolls of fencing, hooks are generally used, while nails are handled by means of a magnet. One 60-horse-power motor operates the hoist while two 20-horse-power motors drive the crane along the tracks.

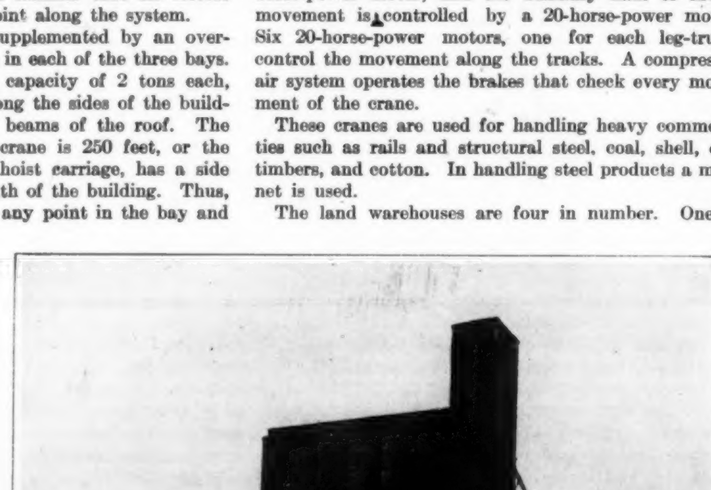
One hundred and ten feet south of Warehouse "C" is Warehouse "D," a duplicate of "C" except that as yet it has not been equipped with cranes and conveyors. To the south of Warehouse "D" is Warehouse "E," 118 by 522 feet in dimensions and built of structural steel and corrugated iron. The south roof of this warehouse is equipped with hatches with sliding doors, which openings permit the transfer of freight from the interior to a ship's hold by means of two traveling dock cranes operating along the south side of the pier. These cranes are of special design and travel on three tracks, one on the apron of the pier and two on the ground. The distance between the dock leg of each crane and the middle leg is 94 feet, the intervening space being occupied by four railroad tracks. The distance from the middle leg and the third leg is 26 feet. The supporting bridge is designed as a truss and carries a plate girder boom 112 feet in length. This boom, in connection with the hoisting carriage operating beneath, has a span of 200 feet. The hoisting crane has a lifting capacity of 11,000 pounds. The hoist carriage carries the operator housed in a cage, from which all movements of the crane are directed. The crane is driven by a direct-current, main-haul, 100-horse-power motor, and the auxiliary haul or lifting movement is controlled by a 20-horse-power motor. Six 20-horse-power motors, one for each leg-truck, control the movement along the tracks. A compressed air system operates the brakes that check every movement of the crane.

These cranes are used for handling heavy commodities such as rails and structural steel, coal, shell, ore, timbers, and cotton. In handling steel products a magnet is used.

The land warehouses are four in number. One of



Interior of Warehouse, Showing Overhead Crane Handling Materials With a Magnet.



Reinforced Concrete Grain Elevator of 500,000 Bushels Storing Capacity.

these, built in 1904, is used for the concentration of cotton and covers a space 80 by 1,200 feet. It is divided into sections of 120 feet by firewalls, equipped with automatic fire doors. The other four warehouses are each 100 by 250 feet, built on concrete foundations with superstructure of cement plaster on metal lath supported by steel framework. The roofs are of cement tile supported by steel framework. The floors are elevated four feet bringing them on a level with car floors. One track extends through the warehouse. Each of these warehouses is equipped with an overhead traveling crane of the same type as those used in Warehouse "C." By means of these cranes cotton and other commodities can be piled in tiers to a height of 22 feet.

The grain elevator, which has a storage capacity of 500,000 bushels, is the first of its kind in the South and affords the cheapest insurance rate of any elevator on the Gulf. It is built of reinforced concrete and is equipped with the latest mechanical devices. There are twelve circular storage tanks 24 feet in diameter and 80 feet high, eight tanks 12 feet in diameter in the working house. Interspliced tanks occupy all the spaces between the circular tanks.

All current, both for the operation of the machinery at the docks and for lighting throughout the city, is generated at the central power plant located in the terminal yards. This plant is equipped with two direct-current, reciprocating engines of 225 horse-power each, and two alternating-current Parsons steam turbines, one 300 kilowatts and one 625 kilowatts. Four B. & W. 250 horse-power water tube boilers complete the equipment.

As a result of the extensive construction work that has been carried on during the past three years the commerce of the port has grown tremendously. In 1904, the first year as a port, twelve vessels arrived and departed, carrying 8,712 tons of cargo. In 1912, three hundred and ninety-six vessels arrived and departed, carrying 463,191 tons of cargo. The foreign trade reached in value $45,213,406. The export movement of cotton was 728,136 bales, valued at $43,293,982, and 628,337 bushels of wheat, which, with the flour movement, reached in value $720,571. The total export movement was valued at $44,685,601.

# Progress in a Puzzling Malady*

## The Stable Fly as the Carrier of Infantile Paralysis

By Charles T. Brues

The fact that several common human diseases are spread through the agency of blood-sucking insects is now quite familiar to the general public, in spite of the very short space of time which has elapsed since any disease was shown to be specifically insect-borne. Nevertheless, it is difficult to realize that scarcely more than a decade separates the present from the time when yellow fever and malaria were removed from the category of mysterious maladies whose method of spread was utterly unknown. These, together with splenetic or "Texas" fever of cattle, formed a nucleus about which has been grouped a number of other human and animal diseases all of which are transmitted by specific insects or closely related animals. Certain mosquitoes, blood-sucking flies, ticks, lice and bugs have thus been shown to be concerned in the spread of disease and their pernicious activities have been carefully investigated from the standpoint of public health.

The most recent addition to the category of insect-borne diseases is anterior poliomyelitis or acute epidemic poliomyelitis, more commonly known as infantile paralysis.

During the past several years a suspicion has been developing among students of this disease that it, too, might result from infection carried by some insect, and the Massachusetts State Board of Health decided to have this possibility investigated during the summer of 1911, under the direction of Dr. Mark W. Richardson, the secretary of the board. Accordingly, as entomologist, the present writer in company with Dr. Philip A. E. Sheppard, who was investigating for the State health authorities the epidemiology of the disease, attempted to determine by observation in the field whether any special insects might appear to be associated with the cases which occurred that season in eastern Massachusetts. Working in this way, it was possible to eliminate many insects which might otherwise have been suspected as carriers, and as the season's work progressed the suspicion gradually grew more and more that the common stable fly (*Stomoxys calcitrans*) might be the insect concerned, especially as the seasonal history, distribution and habits of this blood-sucking fly appeared to fit in closely with the observed epidemiology of the disease.[1]

During the past summer of 1912 Prof. M. J. Rosenau of the Harvard Medical School, who was already thoroughly familiar with the disease, and the present writer, undertook to determine experimentally with monkeys, whether the stable fly could act as a vector for the virus of poliomyelitis. The successful outcome of this work has very recently been announced in a paper[2] describing the experiments in which healthy monkeys developed poliomyelitis after having been bitten by stable flies which had previously fed upon the blood of monkeys infected with the disease. These results have been further confirmed by Drs. Anderson and Frost of the Public Health and Marine Hospital Service,[3] who repeated the same experiments and definitely proved that the disease develops in monkeys which have been bitten by stable flies that have previously fed on monkeys suffering from poliomyelitis.

The stable fly is a small insect very much like the ordinary house fly, to which it is closely related, and for which it is frequently mistaken on account of its size, rather similar coloration and common occurrence in the neighborhood of human habitations. In spite of its close similarity to the house fly, it differs in a number of important respects, both in structure, habits and distribution, and on account of its recently discovered relation to human welfare, it is worth while to mention these briefly.

Stable Fly (*Stomoxys Calcitrans*) Loaned by Dr. Sheppard for Photographic Reproduction.

The adult flies feed exclusively on blood, biting various animals and less commonly, but nevertheless quite frequently, biting persons upon parts of the body where the skin is exposed, or where the clothing is thin. Among domestic animals they occur most commonly on cattle and horses which are often much annoyed by them during the later part of the summer. On account of their feeding habits, the flies are more common in rural districts where the number of animals is large, or in the case of more thickly populated districts, in the neighborhood of stables or places where large domestic animals are most numerous. It is difficult, however, to find any locality of any considerable extent under ordinary conditions where this fly does not occur. Although the flies are found in the vicinity of dwellings, they do not enter homes so commonly as does the ordinary house fly, but rather prefer to remain in the open and more especially in sunny places unless attracted elsewhere by animals or persons. Their normal food consists of mammalian blood and during its lifetime each fly feeds every two or three days, perhaps oftener, upon some warm-blooded animal, less commonly biting human beings. In fact this insect has given rise to the adage that house flies bite before a rain, which is based on the fact that persons are frequently bitten at such times by Stomoxys, which are then apt to come indoors and are mistaken for the house fly. The latter cannot pierce the skin, however, with its soft, blunt mouthparts, while a Stomoxys can readily insert its needle-like proboscis into the flesh. In the writer's experience, however, Stomoxys seems to have more commonly bitten on warm, bright days, although he has been bitten even at night while writing near an electric light. Other observers have noticed that the flies often seek shelter at night. Both sexes are blood-suckers, and become greatly swollen when allowed to feed unmolested. When thus engorged they remain sluggish for a time and are apt to rest with the wings somewhat more widely spread apart than the house fly, and with the body more distinctly elevated, assuming a more sprightly attitude.

If one of the flies is examined closely from above as it rests thus, the proboscis can be seen projecting horizontally like the tip of a fine black pin directly forward from the lower edge of the head. Viewed from the side, the proboscis is seen to emerge from the lower side of the head and then bend forward at right angles for a distance about the height of the head. When sucking blood, the proboscis is straightened so that it projects directly downward from its attachment to the head. In the resting house fly the mouthparts never project forward so as to be visible from above, and this difference will always serve to distinguish the two species at a glance.

Stomoxys appears early in the spring, but becomes much more abundant after midsummer and persists in numbers late into the fall, after the house fly has begun rapidly to disappear.

The breeding habits are much like those of the house fly. The eggs are deposited in small masses; the individual eggs are long, slender, minute objects of a pearly white color. Each hatches into a minute white maggot, slender at the head and enlarging behind to a blunt posterior end. The maggot or larva feeds rapidly, increasing in size and molting twice before changing into the pupa or resting stage from which the adult fly will emerge four or five weeks after the egg has been laid. The pupa is inclosed in an oval brown shell or puparium which is broken open at the head end to afford an exit for the emerging adult fly at the termination of the pupal stage.

The eggs are laid directly upon the materials which will serve as food for the larva. Fermenting heaps of grass, straw and similar substances, horse manure, cow dung and even garbage may serve as breeding places. The relative importance of these different foods is not yet very well known, but it seems probable that this is about in the order named. Excessive moisture is also particularly favorable for the development of the larvæ.

*Stomoxys calcitrans* is very widely distributed over the earth, occurring abundantly throughout Europe, North and South America, the West Indies, northern Africa, Asia, Australia, etc. It is the only member of its genus in the New World, but has a number of close relatives in the tropics of the eastern hemisphere. Whether it is native to North America or is an importation from the Old World is difficult to say, but from its wide occurrence, one would be perhaps inclined to think it native to our own region. At any rate it has been in America for a long period.

The control of *Stomoxys* will probably prove as difficult as that of the house fly and its eradication is obviously impossible. The ordinary flytraps and sticky flypapers which have proved so useful in dealing with the house fly are of no practical benefit in combating *Stomoxys* since it is not attracted to the resinous coating of the paper nor to the baits used in fly traps; as its only food in the adult condition is the blood of living animals, it is attracted only to such and cannot therefore be caught in traps. However, the "coming and going' flytraps devised by Prof. Hodge will undoubtedly catch large numbers of *Stomoxys* if attached

* Reproduced from *Science Conspectus*.

[1] Brues, C. T., and P. A. E. Sheppard. "The Possible Etiological Relation of Certain Biting Insects to the Spread of Acute Epidemic Poliomyelitis." Bull. Mass. St. Bd. Health, December, 1911, pp. 46 to 48 (abstract); *Journ. Econ. Entomology*, Vol. 5, pp. 305 to 324, August, 1912 (full report).

[2] Rosenau, M. J., and C. T. Brues. "Some Experimental Observations Upon Monkeys Concerning the Transmission of Poliomyelitis Through the Agency of *Stomoxys calcitrans*." Bull. Mass. St. Bd. Health, September, 1912, pp. 314 to 317.

[3] Anderson, J. F., and W. H. Frost. "Transmission of Poliomyelitis by Means of the Stable Fly (*Stomoxys calcitrans*). Public Health Reports, Vol. 27, No. 43, pp. 1733 to 1735 (October 25th, 1912).

to the doors and windows of stables and barns. The most important method of control must undoubtedly depend upon the fact that the species develops in manure, decaying grass cuttings, etc. The proper handling of these is a difficult matter but can unquestionably be solved and will aid materially in abating the house fly nuisance as well.

EDITORIAL NOTE:—It is interesting to note the origin of Brues-Sheppard hypothesis of transmission by fly bites. During his investigations of 1910 and early in 1911 Dr. Sheppard had been repeatedly told of fly bites in the history of the cases of infantile paralysis. It was only when Mr. Brues, a skilled entomologist, was selected to work with him in the matter that the particular fly was found. The two men found together in Southboro in August, 1911, that in a family of six children and two adults, all the children were affected, one having been affected also sixteen years before. Two deaths occurred there. The types of disease varied from involvement of the muscle to a fatal paralysis.

Stomoxys was found in great numbers about the barn, on the cattle and about the house, distant one hundred yards from the barn. It was even in the chambers of the house where the sick members of the family were lying. Dr. Sheppard noticed that the flies in the latter room were filled with blood, presumably taken from the human cases.

The conclusion was reached that there is good reason to suppose that mature Stomoxys will carry the organism from one human sick person to another individual by means of its bite. This was the basis of the experiments. It is still to be shown, however, whether this transmission is merely mechanical or that a definite period of incubation is necessary in the fly before it can give infection at once on biting some other person, or whether definite time must ensue before Stomoxys is able to infect.

There will be some further question in the matter as to persistence of the virus in recovered humans. In the Southboro family the girl of nineteen years, who had an attack long before, was upset by some gastro-intestinal difficulty. There is here the question whether with her balance upset she may not have been the origin of the other infections in the family.

# Beauty Doctoring*

## Its Snares and Pitfalls for the Unwary

### By Horace Greeley, M.D.

WHILE familiarity with our imperfections produces an increasing toleration, which often even grows into admiration, "mine" assuming values in units not thought applicable to another, or even appreciable by him, the realism of comparative views frequently prompts a desire to moderate some of the more glaring defects, and leads many to lend ear to even the most extravagant claims of special ability to effect the wished for transformation.

As pretension is the chief asset of the incompetent, it is by them exploited to the utmost, and seems to be the most effective lure for the would-be-beautiful, as nothing short of a promise of as complete and as wonderful a transformation as Medea effected upon old Æson seems sufficient to content or even to induce them to submit to treatment, which, of the proper kind, intelligently applied, might, in some cases, effect great improvement. But no, as usual the fool by folly led is caught by the greatest glare, and commits that which she is most concerned about to the bungling hands of some ignoramus, who rarely learns enough, even after extended "practice," either to paint a face or dye a coiffure acceptably.

Manicures, hairdressers, barbers, bath-rubbers, masseuses, and even actresses, whose vanity, tempted by trashy newspapers, leads them into ridiculous explanations of how they attained and maintain what is frequently a supposititious beauty, furnish the most recruits to the ranks of these so-called beauty-doctors. It may seem strange that any one should be permitted to do what is actually practicing medicine, as defined by law, without either education or license; yet the public's attitude of indifference, together with the State's recognition and licensing of various procedures encroaching upon this sphere, and the toleration of the prescribing druggist and patent medicine man have so lowered the lay estimation of the healing art as to permit sympathy with, toleration, and even patronage of these people who are really somewhat justified in the claim that their work is thrust upon them. The manicure is required to produce pink, smooth, rounded, tapering nails, and even fingers out of the most unpromising material; to whiten hands, remove freckles, hair, etc., and, unless she at least supplies "hopeful" treatment, is condemned to business failure. Woe to the hairdresser or the aspiring barber who knows no sure method of rejuvenating, tinting, and even of restoring the hair. If a bath-rubber and a masseuse do not confess to a touch sufficiently magic to stroke away a wrinkle, a double chin, or an overplusage of avoirdupois, no matter where located, how may they hope to rise? And so on; the experience of one temptation after another finally turning out a complete "beauty specialist" with claims to suit all comers.

Some will ask why are there no regularly licensed practitioners who do this work? Of course, but their advice and methods, when consulted, are too simple, and their promise not great enough to suit the clientele. In fact, ethical medical men avoid such work, so much has it been brought into disrepute by these people, and are very diffident in giving advice in cosmetics.

In proceeding we will try to show all real possibilities of this work, and both by exclusion and direct consideration demonstrate the baselessness of some of the most far-fetched pretensions.

*The Hair-coloring.*—If one must have a remedy for grayness, there is no other recourse than to artificial staining, notwithstanding a recorded instance of the natural change from black to gray, gray to black, and then again to gray in the case of a man during a period of some five years, and a few other similar though less remarkable suggestive instances. The only effective dyes are those by the use of which a precipitate is formed on the hair, practically a plating or coating; and, as those who have had experience know so well, they never give a satisfactory result; at best a dead, unnatural color is obtained, and very frequently undesirable shading, where sufficient has not been applied or the coating has worn off, leaving a purple, or even a red tint. It has been said that "Indignant Nature hides her lash in the purple hues of a dyed mustache."

As a preliminary to any staining of the hair it must be washed with an alkali, such as ammonia, and this, especially when applied in strong solution or too frequently, causes it to become very brittle, and consequently soon reduces its bulk greatly. Subsequent to the alkaline wash a solution of nitrate of silver is brushed on, carefully avoiding the scalp (yet for a good result the hair nearest the skin must be thoroughly covered) and allowed to dry in the direct sunlight, during which process it changes into silver oxide, a black. A red tinge or a brown is reached by varying the strength of the silver solution. The same results may be obtained by similarly precipitating an oxide or a sulphide of lead or mercury; but these last named have, when carelessly brushed on the scalp in some quantity, occasionally given rise to symptoms of poisoning. A red tinge is also sometimes given to light hair by the use of an infusion of henna leaves or of logwood. Brown, more or less fugitive, may be imparted by a solution of the coloring matter from the outer husks of the native black walnut, such as the country small boy has such difficulty in removing from his hands in the fall. A light shade of the same is sometimes produced by a preparation of tannic acid which, for the color in question, usually gives better results than the other dyes.

To tinge dark hair, a degree of bleaching must be effected, always by the use of peroxide of hydrogen, and, by varying the number of applications, after the preliminary removal of the oil by the alkaline wash aforementioned, this is made a brown, dark or light according to wish, or even a reddish shade may be left by adroit management. Of course, apart from the tendency to extreme brittleness produced by the alkali, no actual harm is done, if, in the case of the dyes, the scalp is avoided, and we can tolerate the blend of color so frequently obtained. Bleaching is not so troublesome, and can be effected fairly well by oneself without danger, except the resulting brittleness. Yet nine out of ten fail to reach the back and more inaccessible portions of the hair, and always overbleach the front and ends. We often hear blondes complain that their hair is growing darker at the roots or in the back, when nothing but their own unequal applications or failures first to remove the oil from the hair are to blame.

Of course there is no such thing as a hair restorer, and when once a hair has dropped out from the changes incident to advancing age (and this is the only cause for general falling of the scalp hair, except severe acute illness) nothing will replace it. It is very much like pouring water on a rotten stump, expecting to regrow the tree, to dump the various tonics on one's scalp. Most of them contain nothing possessing even a good pretence of action when applied to the scalp, although some have irritating properties which are supposed to stimulate the local circulation of blood, but for what? The hair-root died before the hair fell out, and there is no known method of reviving it. Recently, however, an enterprising Frenchman has found a way of seeming replacement wherein, as in a child's garden planting, the broken off tops are stuck in. He fastens a hair to a bit of gold wire, and pushes the wire beneath the skin, allowing the hair to protrude, and repeats the procedure till the required number have been placed, or, perhaps, till he or his pin-cushion patient is exhausted. Of course they do not grow and are not expected to do so, and all will soon break off, so that such frequent repetitions of the process are necessary as to make it improbable that anyone except a widower on the trail of the teens would submit.

Quinine, much vaunted as a hair restorer, has no effect whatever, unless in large quantities, when it acts as a mild antiseptic, none in the proportion used in the so-called "tonics;" and the popular egg-shampoo is a poor substitute for soap and water.

Although dandruff is part of a general skin disorder, usually dependent upon general ill health or poor digestion, and is best got rid of by removing the cause, some temporary good may be accomplished by the use of mild antiseptic washes (usually a solution of resorcin), but the sure-cure advertised as due to such preparations is very slow and uncertain in materializing. As the underlying conditions improve, the dandruff disappears, and no permanent cure is possible otherwise.

Preparations claimed to curl the hair contain gum-arabic, and those to straighten it, wax; so how each of these might feebly act in the indicated direction is readily appreciated. The plantation darky's corn-silk and grape-vine decoction has never become popular, perhaps only because our hair is inclined to be straight, and our sighs are all for curls. I know a woman who regularly uses the ashes of wood-shavings (secured in long spirals) and who cannot be convinced that those of a fence-rail would do as well, as it is only the lye obtained which, by removing the oil, encourages her curly locks. I hardly think any reader would try a hair-oil, which, if ever used, is best made of castor-oil and alcohol. The much vaunted singeing of hair, to stop splitting, only burns off what a pair of scissors would more easily remove without doing the damage wrought by the heat, which chars or renders very brittle the remaining part of the hair for an inch or more below, and actually does harm.

The face, however, supplies what the French call the *point d' appui* of the "beauty doctor's" prentice-hand, and on it most of his pretensions are lavished. Nearly all the measures employed are both harmless and totally ineffective, comprising applications of lotions of glycerin and water flavored and colored in infinite variety; creams, greasy and greaseless; both lotions and creams variously fortified with one or more of the subterfuges with which empiricism has endowed the pharmacopeia. The glycerin contained in the lotions, while some remains on the skin, acts as a lubricant and, by making it temporarily slightly more pliable, conveys the impression that it may permanently modify it in this direction. Some lotions contain carmine and consequently impart a pink tinge. The grease creams, such as cold-cream, a composition, principally, of oil of almonds, flavored with rose-water (although cheaper fats are commonly used), are either modifications of this, or made with a base of wool-fat, vaseline, cocoa-butter, castor-oil, all with varying proportions of wax to add consistency, and frequently a little whale-fat (spermaceti) is thrown in without any good reason. Flavors are given to suit, and many are colored, as "cucumber-cream," which sometimes, besides being dyed light green, has some cucumber juice added to supply the appropriate odor. Why this vegetable is used is hard to tell, unless as it is said to have the odor of rattlesnakes, in imitation of the savages who superstitiously anoint their bodies with snake oil, to make them supple.

* Reproduced from the *Medical Record*.

Greaseless creams contain gelatin or starch appropriately flavored and colored, and their only use is as a substitute for water when one has an intuitive dislike to familiar contact with that so-called element, of primary education, and so enable her ladyship to cultivate a superficial hydrophobia; but, as they carry away with them, when rubbed off, much of the dirt, they are useful.

A "skin-food" is one of these creams, and is of course nothing but an absolute fraud, having no action in the direction implied, as it is as reasonable to try to fill a pitcher by setting it in a basin of water as to expect an appreciable amount of the fat rubbed on to penetrate the cuticle. Anyway the skin as it is popularly known is not nourished by fatty materials.

"Toilet-milks" are emulsions (suspensions in water) of the various creams, and of course are similar in effect. "Jellies" consist of gelatin, gum arabic, or starch added to one of the lotions, and are equivalent to greaseless creams.

*Freckles*, which are but points of greater skin color-production stimulated by the increased need of protection from the strong light of summer, are commonly treated by the application of a corrosive lotion, universally a dilute solution of bichloride of mercury, which is usually repeated at intervals of several days until the most superficial layers of the outer skin become detached. The greater smoothness and less stained character of the remainder, together with an effect of the mild irritation, an increased blood supply, produce a slight temporary improvement in skin finish and coloring which lasts for some days. Of course the seat of pigment production lies beyond reach of the method, but at least the superficial coat is removed, and the rest is partially concealed as stated. If such a procedure be used too frequently, and it can rarely be repeated more than once a month, marked actual harm may be done, the skin becoming much roughened and possibly discolored. Really, under the best circumstances, the result is hardly sufficient to save the whole thing from being decried as an absolute fraud. It, however, furnishes a means whereby the customer may be deluded into further patronage, thinking that, as with the imperfect pearl, peeling may reveal a luster unknown before; and although the attempt may not, as with some of these gems, be disastrous, yet, were her ladyship's expectations to be realized, she would have to be all skin like an onion, and would be finally peeled away by the repeated efforts to reach the peach-blow she fondly imagines lies somewhere beneath. Some bleaching of the surface of the skin may be effected by long continued use of peroxide of hydrogen, each time after a good soaping. So-called black-heads, large-mouthed skin glands whose oily discharging secretion has become darkened by dirt, may be made to disappear with a good scrubbing with soap and water, although a fat dissolving lotion frequently used will do the work.

*Wrinkles* are due to two causes: One the increasing loss of elasticity from which the skin suffers in common with articles made of rubber, which the more extensively and more frequently they are stretched the less complete their return to their former state and size, and changes in the skin bed, such as the absorption of fat therefrom, alterations in the shape and size of muscles and bones, which latter of course only affect the larger furrows. As there is normally great individual variation in skin elasticity the tendency to wrinkle varies accordingly. The treatment of this condition, apart from the peeling process above detailed, which in the temporary glow and freshness resulting conceals, as spring the ravages of the passing winter, the furrows and ridges beneath, is attempted by applying adhesive plaster, collodion, or even bandages, all of which act by temporarily protecting the skin from the creasing action of the underlying muscles till body fluids have distended the underneath tissue interstices, or have produced this last effect by inducing capillary dilation, as a plaster does through increase of warmth, or by withholding some of the air pressure, or both. As will be understood from the foregoing it is extremely doubtful whether permanent results can be attained by anything short of permanent treatment, but one thing, however, is certain, and that is, that the nuisance involved is never justified by the result, for the improvement is barely noticeable. Some of these special "specialists" "cure" wrinkles by covering all with a nasty smear of paint and powder or the so-called enamel, a suspension of various powders (calamine, a pink, talcum-like substance is a favorite) in glycerin, which is painted on, and, as the glycerin does not dry, neither blows away nor cracks if reasonable thickness is not passed.

Grease paints are combinations of olive or of sweet-almond oil with wax and various colors; often the cheaper kinds are made of other fats with paraffin instead of wax.

All good rouge is prepared in France from the safflower, a plant grown in the East, and its precipitation upon the little china disks on which it is sold is so much of an art that attempts at imitation in this country have been too costly to make competition profitable. Still more is sold than of any other cosmetic, and, even if we decry its use as removing some of the incentive to improve one's health, we cannot pretend that it has any harmful effect whatever on the skin. So let us be content with proclaiming that here a crime is committed only when the criminal is detectable, as is sometimes the case in much graver matters.

A great many face preparations are denominated cerates, which implies a content of beeswax, used to stiffen the ordinary grease-cream, and so act similarly, the only difference being that their greater consistency permits more to be rubbed on, and then not to be so easily rubbed off.

Certain procedures applied to the hands come under our subject, for, in addition to the use of the various lotions, creams, etc., to small or to no purpose, some pretenders claim to be able to remodel the hand, and do it up in bandages or plaster. They are able, for a while at least, to delude some shallow wits into the belief that the joints are becoming smaller and the fingers more tapering, which seems to be the goal of hand-beauty, unless we recognize the demand of some for sharpened nails, a development that they can hardly expect to use either for offense, defense, or convenience; although I did know an individual who avowedly grew the left little finger-nail to special length for toilet uses, and the famous Lady Mary Whortley Montague, when reproached by a friend for her dirty nails, replied that she must scratch. In reality, nothing except protection from the effects of work in inlarging the joints or in roughening the skin will add to the existing symmetry of the individual hand, so that hand rest and the constant use of gloves will accomplish more than the most pretentious beautifier advertised in print or by reference.

As to the nails, one's own ordinary care in trimming and cleaning gives results fully equal in attractiveness to the *chef d'œuvres* of the manicure, whose tinting and waxing so interfere with the natural color-blending with the adjoining skin as to make the exhibit as unpleasing as the varnished hoofs of the Central Park hackney.

Since we have got so far in our subject it would seem incomplete did we not mention some of the methods not usually undertaken by others than licensed practitioners. There are many so-called depilatories on the market, all having as a base one of several substances similar to calcium sulphide (popularly unidentified except by its odor) which, when made into a paste with water and spread and allowed to remain on the offending hairy area for a minute or two, will destroy that part of the hairs above the skin surface. This, of course, requires repetition every few days, in fact oftener than the method of pulling the hairs out with a pair of tweezers, and is only better than the daily pumice stone rub, to grind off the previous twenty-four hours' growth, or the regular shave. Possibly the regrowing hair is stronger than before, but it is more than probable that it is so in appearance only, as what was previously a part of the stump has been pushed out till it has become the tip, and the softening effect of the original taper has been lost. Of course after a time each hair would be worn to a point by friction, which is the natural cause of the original taper. There is a great sale for many of these depilatory preparations, although, if one is not satisfied with the result of daily applications of peroxide of hydrogen, which bleaches even quite large hairs into comparative invisibility, the electric needle of an expert, actual, and not in name only, lest disaster be courted, had better be sought.

By this method, one sitting a week of an hour's length enables the operator to attack about fifty hairs by thrusting his little needle along each of their shafts, and then having the patient touch the other electrode, which, by a contact of about half a minute, causes destruction of the hairbulb or root, in those cases where the needle has accurately reached it, in about two thirds of all careful attempts. Repeated sittings are of course required, and all failures necessitate a re-attack. Of course all this is tedious, expensive, and somewhat painful, but there is no easier thorough way. The X-ray has been used, but is very dangerous, and usually the growth returns stronger than before.

Moles and warts on most of us who are not as ugly as Oliver Cromwell are such distinct detractions that it is surprising how many make pets of theirs, refusing even entreaties to allow a clip of the scissors, if not to make classical, at least to generalize their features.

While individual muscles may be enlarged by special exercise, local fat deposits cannot be influenced, except in common with the general padding of the entire body, notwithstanding all the gyrations and regimens, as ridiculous as the pretensions of those who recommend them, propounded by the professional beauty claimants of the day.

As a most horrible warning against the anti-fats of the advertisers, I quote the case of a 235-pound woman who told me to-day that she recently sent $25 to one of them for their "specific," but was so worried by the appearance of one of the capsules received, which was labeled "special," to be taken last, that she sent it to a laboratory for examination, and, I think, was permanently cured of her "reducing" mania when it was reported to contain the head of a tapeworm.

Many "anti-fats" have been found to contain thyroid-gland substance, and are fortunately rarely taken by anyone for a long period, as careless administration of this drug is thought to be dangerous, although in at least some cases, and to some degree, it is undoubtedly effective.

The foregoing covers at least most of the real cosmetic possibilities, though, of course, as analysis has so frequently disclosed, many of the advertised nostrums contain nothing pharmacodynamically effective, and sell on their label, their color, and their flavor, trusting for credit to what may be called the innate Christian Science of their purchasers.

## On the Antiseptic Properties of Spices

It has been the fashion, or habit, for twenty-five years to imagine that the great majority of things which we like are injurious to our health, or simply less desirable than many other things for which we have no liking. This misconception is largely due to a superficial acquaintance with physiological chemistry, and it is a pleasure to discover that a more profound knowledge of the question permits us to affirm to-day that the individual taste in the majority of cases is a sure guide to a régime most suitable to the health of the individual.

Among the matters which constitute human nourishment the spices have been the most recent to give up their secret. It has been frequently stated for a number of years that spices are hard to digest and that they were more to be regarded as stomach irritants than as means of stimulating the digestion. It is recognized to-day, however, that as a general rule the foods for which we have a liking are the most favorable to our health. It is, of course, understood that if we eat too much of it the most palatable food may become dangerous. An excess of anything is, of course, always dangerous. In this respect the human race has recently had some very interesting experiences, and oftentimes great scientific disillusions. As an example, we may take gelatine.

When gelatine was discovered it was thought to be an ideal concentrated nourishment, containing all the chemical elements which constitue the great majority of the elements of the human body. Gelatine was considered to be sufficient in itself as a foodstuff, or at least that with a certain daily ration of gelatine one could dispense with all other food. It was said that although gelatine was rather insipid and its daily consumption might become repugnant, nevertheless with the addition of certain foreign substances, such as sugar and spices, it would be easily absorbed. But it was finally perceived, in spite of the affirmations of the chemists of a former epoch, that gelatine had practically no nutritive value.

We may cite as another example mushrooms, which in spite of their delicate taste and their relatively high content of nitrogenous matters, furnish practically none of the elements necessary for the building up of the human body.

The more the modern physiologist studies the question the more does he perceive that taste is a sufficient guide in the choice of foods.

Hoffman and Evans, in studying the preservative properties of spices, have demonstrated in a convincing fashion that certain spices, such as cinnamon, cloves and mustard, are without doubt excellent preserving agents for foods, and that pepper and nutmeg to a certain extent retard the development of many kinds of bacteria in foods with which they have been incorporated. The true preserving agents of spices are the aromatic essential oils contained in them. The essential oil of mustard is an active antiseptic. Besides its essential oil, cinnamon contains an aldehyde which belongs to a group of chemical substances analogous to formaldehyde. It has been declared by competent chemists that an aldehyde obtained from cinnamon has an antiseptic power equal to that of benzoic acid. It is claimed by them that foodstuffs prepared with the addition of this aldehyde keep much longer than foods not containing it. They also claim that the employment of cinnamon and cloves is in no way dangerous to health, and that these substances are rather beneficial and appetite-creating.

Nature is very versatile. It has often been asked why the inhabitants of tropical countries are so partial to spices, mustard, Cayenne pepper, black pepper, paprika, etc. Is not the reason for this the increased tendency of food-materials to decompose in a hot climate?—*Pure Products.*

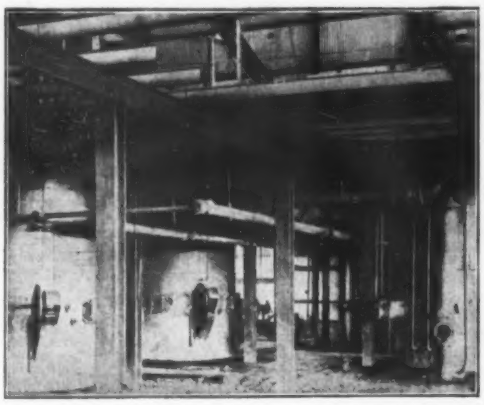


Fig. 1.—Typical Down-draft Producer Plant for Texas Lignite.

Fig. 2.—Up-draft Gas Producer for Bituminous Coal With Motor-driven Tar Extractor.

Fig. 3.—1,000 Horse-power Producer Plant Operating on Illinois Bituminous Coal, Alton, Ill.

# Producer Gas* for Power Purposes

# Chemical Principles and Mechanical Factors in Its Manufacture

By H. F. Smith

The most fundamental chemical reaction in a gas producer is the combination of carbon and oxygen to form the two oxides of carbon, namely, CO and $CO_2$. It seems to be established with a fair degree of certainty that these oxides of carbon are produced in the order named. Incandescent carbon being brought into contact with oxygen combines with it to form the single oxide of carbon, CO. It may, therefore, with propriety be called the primary oxide. On being mixed with additional oxygen this primary oxide is further oxidized to $CO_2$. Both of these reactions are reversible. Under suitable conditions $CO_2$ will surrender one oxygen atom with the formation of CO, while under different conditions CO will combine with one oxygen atom to form $CO_2$. The same is true to a limited degree of the primary oxide of carbon—CO. Under suitable conditions oxygen will combine with carbon to form CO. Under other conditions CO will split up, liberating oxygen and free carbon. It has been pointed out recently that with reversible reactions of this character the conditions determining the direction of the reactions may overlap, and, in fact, frequently do overlap so that we can have existing at the same time conditions causing the decomposition of $CO_2$ by carbon, whereby CO is formed and conditions in which CO will take up additional oxygen with a resulting formation of $CO_2$. In fact, it seems that both these reactions occur simultaneously in practically all conditions that are met with in producer operation. The extent to which one reaction predominates is determined by conditions. For any given set of conditions, a state of equilibrium will finally be attained, in which the rate of production of CO from $CO_2$ is exactly equal to the rate of production of $CO_2$ from CO, so that no change in the relative proportions of these constituents will occur, no matter how long the conditions are maintained without change. The conditions governing the rate at which these reactions occur in a gas producer are the same as those governing the rate of chemical reaction in general.

* Paper presented before a joint meeting of the Electrical Section, W. S. E., and the Chicago Section, A. I. E. E., and published in the *Journal of the Western Society of Engineers*.

1. The rate of reaction as well as the direction of reaction and the final condition of equilibrium depend largely on temperature.

2. The rate of reaction is determined by the degree of molecular contact between the reacting bodies, or, in other words, by the extent of surface exposed to the reaction.

3. The extent to which the reaction proceeds will be determined by the time of contact, so long as this time of contact is shorter than that required to obtain complete equilibrium where the reactions concerned are reversible. Since the time available for the reactions occurring in a gas producer is nearly always less than that required for the attainment of complete saturation equilibrium, this element of time of contact becomes one of considerable practical importance.

To illustrate briefly, these three fundamental principles are concerned in practical operation of gas producers, as follows:

1. The rate of gasification of fixed carbon rises with increase in temperature. The equilibrium ratio of CO to $CO_2$ also rises with increase in temperature. This means that high fuel bed temperatures permit a rapid rate of gasification, and also permit the production of gas with a high content of CO and a relatively low content of $CO_2$. Conversely, with a low fuel bed temperature it is impossible to secure high rates of gasification of fixed carbon, and it is likewise impossible to secure a high ratio of CO to $CO_2$. In other words, with low producer bed temperature the percentage of $CO_2$ in the gas is bound to rise and that of CO is bound to fall, other conditions being equal.

2. The rate of gasification of fixed carbon is determined in no small measure by the total area of contact between the carbon and oxygen. Obviously, chemical union between two substances can take place only at their surfaces of contact. With a given degree of molecular activity, as evidenced by the temperature, a certain definite rate of combination per unit area of surface will occur.

From this it is clear that the rate of gasification of fixed carbon will be increased by increasing the surface of carbon exposed to the blast. It is on this account that some of the producer fuels, such as charcoal can be gasified more rapidly and attain to the normal state of equilibrium between CO and $CO_2$ for a given temperature more quickly than is the case with dense, non-porous fuels such as anthracite. Obviously also, the size of pieces of fuel constituting the fuel bed will have a marked influence on the surface exposed. If no other element than this were considered, the smaller the particles of fuel the greater would be the surface exposed in a given cubical space, and one would expect a more rapid gasification of finely divided fuels than of coarse fuels. With very fine pieces, however, the access of gas to the surface of the fuel is obstructed owing to the fact that the small particles lie much more closely together. In a practical way this is very intimately related with the third element, namely, time of contact.

Chemical reactions are by no means instantaneous, and under a given condition of temperature considerable time is required for the attainment of the condition of equilibrium between CO and $CO_2$. To give a concrete idea of the time actually required under given conditions for attainment of equilibrium, we quote from the recent investigation by the United States Bureau of Mines, as follows:

"At temperature of 900 deg. Cent., time of contact required to attain practical equilibrium, 142 seconds.

"At 1,000 deg. Cent., time of contact required to attain practical equilibrium, 123 seconds.

"At 1,100 deg. Cent., time of contact required to attain practical equilibrium, 90 seconds.

"At 1,200 deg. Cent., time of contact required to attain practical equilibrium, 18.9 seconds.

"At 1,300 deg. Cent., time of contact required to attain practical equilibrium 8.8 seconds."

These rates are observed for charcoal, which is very porous and has a largely extended surface. For anthracite at a temperature of 1,100 deg. Cent., 34 seconds of contact were required to reach the same degree of saturation as is attained in 30 seconds with charcoal. At 1,200 deg. Cent., 47 seconds are required for anthracite as com-

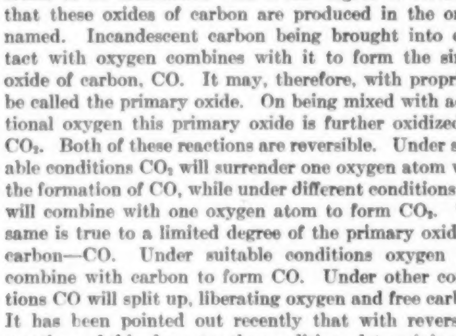


Fig. 5.—Soft Coal Suction Producer-gas Engines Driving Alternators and Air Compressors.

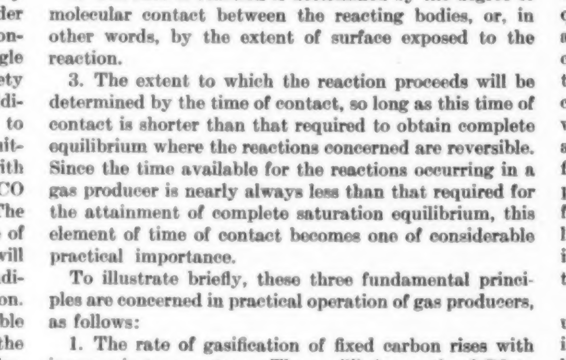


Fig. 4.—Mechanical Tar Extractor for Use in the Purification of Producer-gas.

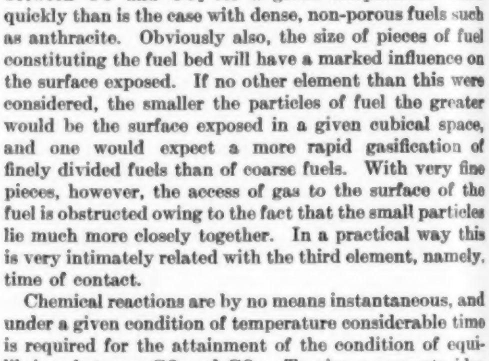


Fig. 6.—Smith Recording Gas Calorimeter, with Sampling Pump and Pipe Connections.

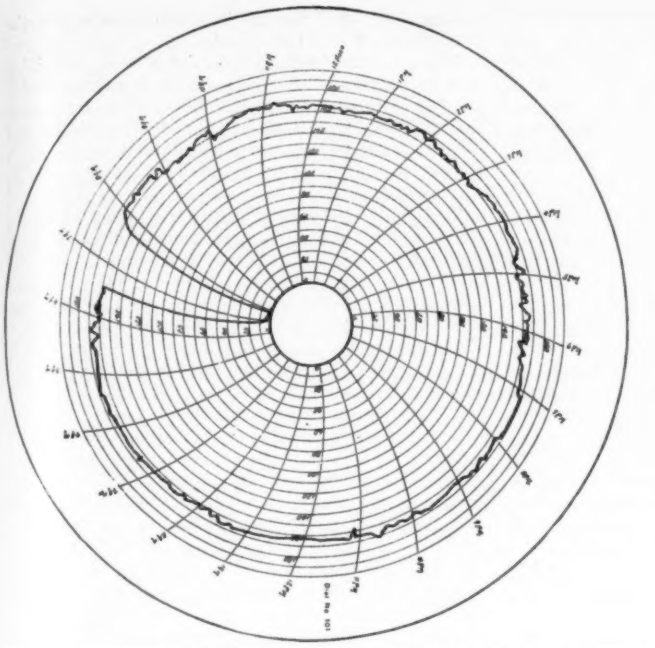


Fig. 7.—Continuous Calorimeter Record from Plant Operating on Texas Lignite, Illustrated in Fig. 1.

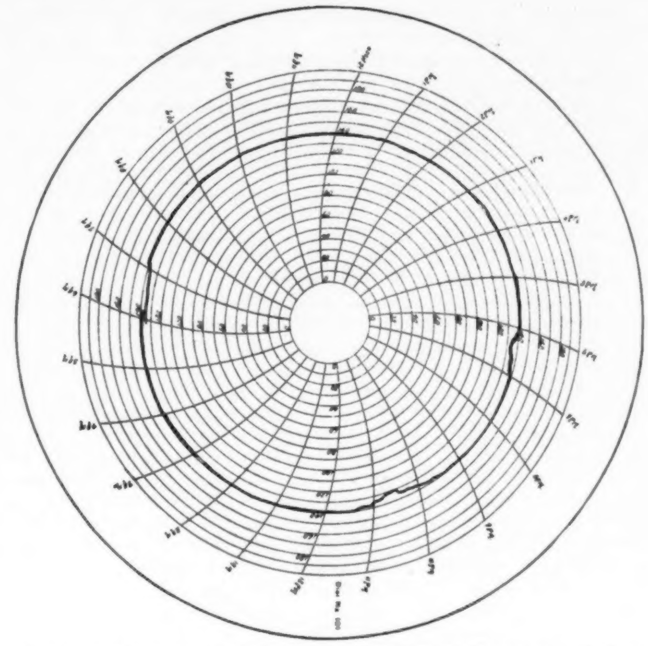


Fig. 8.—Calorimeter Record from Plant Illustrated in Fig. 4, Illinois Bituminous Coal.

pared with 19 for charcoal. At 1,300 deg. Cent., 12 seconds are required for anthracite to attain the same degree of saturation attained in 9 seconds with charcoal. This would seem to indicate clearly the influence of extended surface on the rate of oxidation of carbon, and more particularly on the time required to reach the highest possible ratio of CO to $CO_2$ for the temperature. These principles are of the utmost importance in connection with the practical design and operation of producers.

So far we have considered only gasification of fixed carbon. In the operation of producers on anthracite, coke and the like, this is the chief reaction. In connection with this, however, must be mentioned the decomposition of water vapor, which is made use of to bring about higher producer efficiency by utilizing the surplus heat of the initial combustion of carbon to CO, and by the endothermic quality of the reaction to reduce the temperature of the fuel bed. While many other methods of controlling fuel bed temperature have been suggested, none has met with the universal acceptance and adoption characterized by the use of steam. That there is ample reason for this might be suspected from the rather intimate relation between carbon and hydrogen in a chemical way. Not only is water vapor decomposed by hot carbon into carbon monoxide and hydrogen, but it has been recently discovered that the presence of hydrogen in some form is absolutely essential for the further combustion of the carbon monoxide. Perfectly pure carbon monoxide gas will not burn in pefectly pure oxygen. The presence of hydrogen in some form seems to be essential to bring about the combustion of the carbon monoxide to carbon dioxide. If a jet of perfectly dry hydrogen-free carbon monoxide gas is lighted in air it will burn freely provided the air contains moisture. If, however, the burning jet is brought into contact with perfectly dry air it is immediately extinguished. The chemistry of hydrogen and carbon are still more intimately associated in that compounds are formed of these two elements in almost any proportions. Carbon will combine directly with hydrogen under suitable conditions with a production of methane, and all of the ordinary fuels contain considerable quantities of hydrogen and carbon in combined form. The chemistry of these hydrocarbon compounds is a subject that is but imperfectly understood. It is a matter, however, of the highest importance to the producer-gas engineer, particularly where fuels containing a considerable quantity of hydrogen and carbon in combination are to be gasified. Aside from its property of promoting the combustion of carbon monoxide, and of combining in all proportions with carbon, hydrogen has another important property of material interest to the producer industry, particularly as it relates to the application of producer-gas to gas engines. This property is its enormous rate of flame propagation, and has often been confused with ease of ignition. It has been frequently stated that hydrogen is a potent cause of prematuring and backfiring on account of the fact that it is more readily ignited than the other constituents of producer-gas. This, however, has little foundation in fact. Hydrogen will not ignite at materially lower temperatures than carbon monoxide or methane, but having once been ignited the rate at which the flame is propagated by hydrogen is enormously greater than the rate of flame propagation in any other combustible gas. Carefully conducted experiments on this subject show that under favorable conditions the rate of flame propagation in explosive mixtures of hydrogen and oxygen will reach the rather startling figure of 2,000 feet per second. It is largely on account of this property of increasing the rate of flame propagation in mixtures containing hydrogen, that it is so highly important to control accurately the percentage of free hydrogen contained in producer gas. The entire elimination of hydrogen is not only impossible but most undesirable, but if the rate of explosion is to be maintained anywhere near constant the percentage of hydrogen in the mixture must be controlled with great accuracy.

Some few items in connection with the chemistry of the hydrocarbon compounds are of interest in the manufacture of producer-gas. The composition of these bodies may be altered simply by the application of heat, in which case the compounds are split into two portions, one of which is less complex and the other more complex in composition than the original compound. These bodies may also be reduced by combustion with oxygen, and while there are many evidences that selective combustion—that is to say, the combustion of hydrogen in preference to carbon in a limited air supply—does not occur, nevertheless, there are conditions arising in which the total results of reaction are the same as though this selective combustion did exist. Accordingly, when hydrocarbon vapors are burned in the presence of a limited air supply, the products of combustion usually consist of water vapor—carbon dioxide—and free carbon in the form of lamp-black or soot. These two properties are mentioned in connection with hydrocarbon compounds, for the reason that both have been made use of to a considerable extent in an attempt to produce fixed gas from the various hydrocarbon compounds in coal.

The relation of these chemical principles to producer design is readily perceived. In the manufacture of producer-gas there are three distinct steps.

1. The preparation of a suitable blast consisting of the various elements which it is desired to combine with the fuel.

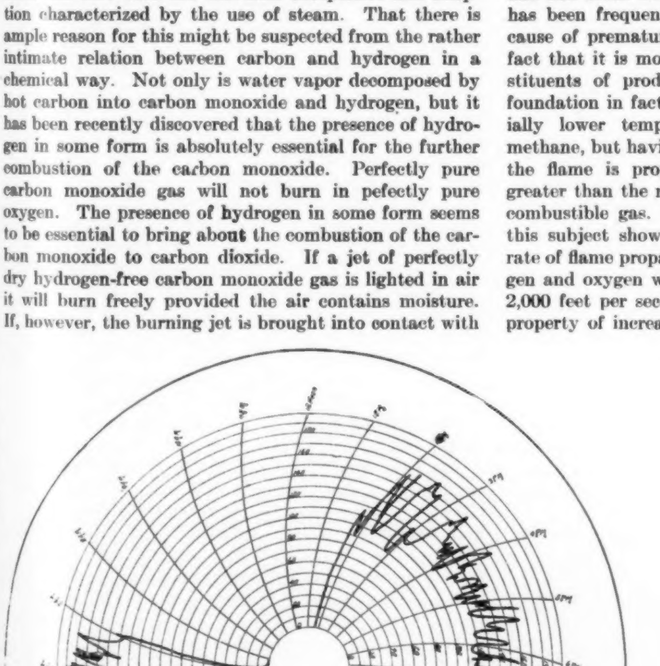


Fig. 9.—Showing Rapid Variations in the Thermal Value of the Gas.

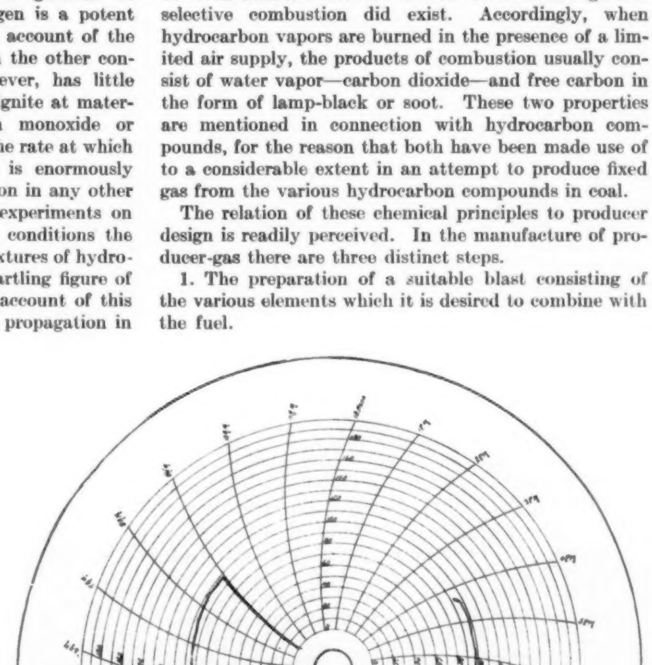


Fig. 10.—Calorimeter Chart Showing Record on Blast Furnace Gas.

2. Bringing about a combination of the elements in the blast with the fuel to be gasified.

3. Cooling and cleaning the gas to render the same suitable for use.

In producer-gas for power it is of the highest importance that the gas should have as nearly uniform composition as possible. As a first step toward the production of uniform gas, it is necessary that the blast supplied to the producer should be of uniform composition. In other words, a constant ratio must be maintained between the oxygen and water vapor in the blast. Without taking time to go into detail concerning the various methods that have been suggested for this purpose, it may be remarked that so far only one method seems to meet all requirements. It is a well-known principle in physics that air at a given temperature will take up a definite proportion of water vapor and no more. It will take up water by evaporation until its point of saturation is reached, provided, of course, that it is kept in contact with a sufficient surface of water for a sufficient time for this saturation to occur. The temperature of saturated air, therefore, is a direct measure of the amount of moisture contained in it, and if we supply to the producer saturated air at a constant temperature, we will supply a blast containing a definite and constant proportion of moisture. This method of vapor control is the only one that compensates fully for the normal daily and seasonal variations in atmospheric moisture. All mechanical appliances for measuring off a definite amount of water to be evaporated into steam are defective in that however perfect they may be intrinsically, they cannot possibly compensate for variation in the moisture content of the air supplied to the conditioning apparatus. The air for the blast can be readily heated and conditioned with regard to moisture by bringing it into contact with an extended surface of hot water. In this way there is no direct introduction of vapor into the blast

In bringing about the combination of the various elements of the blast with the fuel in the producer, many items demand consideration. We have noted above that the conditions determining the rate of producer reactions are, (*a*) temperature; (*b*) surface of contact between the blast and fuel; (*c*) time of contact between the blast and fuel. The temperature at which the fuel bed may be maintained for continuous operation is determined by the fusing point of the ash contained in the fuel. Unfortunately, most American coals have ash that is fusible at a relatively low temperature. The temperature at which the producer may be operated being thus strictly limited by the nature of the fuel, the lack of fuel bed temperature must be compensated for by increasing both the surface of contact between the blast and the fuel and the time required for the blast to pass through the fuel bed. These requirements demand the construction of a producer not only of greater sectional area but of greater depth than would be required for a fuel that would permit the use of higher temperatures. A brief consideration will show that the size of fuel fired to the producer has considerable influence both on the surface of contact and time of contact between the blast and fuel. If we assume a producer of given sectional area the time required for the blast to pass through a given depth of fuel would be directly proportional to the total area of voids in the fuel bed. The larger the pieces of fuel the greater the percentage of voids, and consequently the slower the rate of blast passage through the bed. On the other hand, the smaller the pieces of fuel the greater would be the ratio of surface to mass and consequently the greater would be the surface exposed to the action of the blast. We have, therefore, with regard to size of fuel, two variables, the resultant of which we would expect to reach a maximum for some particular size neither the largest nor smallest. This, indeed, is found to be the case. With anthracite, for example, the maximum capacity for a given depth and sectional area of producer is obtained with coal that will grade through 7/8 inch and over 9/16 inch square mesh screen. This coal is ordinarily marketed as pea. Larger sizes of anthracite, while permitting a slower rate of gas passage and a longer time of contact, present a surface so much reduced in total area that the capacity of the machine suffers distinctly. On the other hand, small fuel, while presenting an enormous surface, so completely occupies the voids that the gas velocity through the relative small area remaining is so high that the time of contact is insufficient and the producer capacity is accordingly reduced.

In the actual design of the generator chamber it is important not only to proportion the diameter of the producer and depth of fuel bed properly in relation to the fuel to be used, but it is also very necessary to take some steps to insure a uniform distribution of blast over the entire sectional area of the producer. Since temperature is the limiting factor, if any portion of the fuel bed is driven at a more rapid rate than normal this portion must necessarily reach a higher temperature, and may even exceed the permissible temperature for the particular coal used, and cause fusion of the ash and clinkering. The principal difficulty in securing blast distribution is to prevent too rapid driving next to the producer lining. There is always a tendency for the fuel bed to be more porous and open next to the lining than elsewhere, and if the bed is simply maintained on a flat grate with a fuel bed of uniform depth discharging into a gas space extending over the whole upper surface of the producer section, the temperature next to the lining will be much higher than in the center of the fuel bed. It is accordingly very desirable to arrange the fuel bed so that the resistance next to the lining will be augmented. In the ordinary water bottom type of producer this is frequently accomplished by locating the air inlet in the center of the fuel bed, discharging the blast into the fire through a central tuyere, so that to reach the lining it is necessary to pass horizontally through a considerable depth of fuel. This would be a highly desirable method were it not for the fact that the concentration of the blast has a tendency to increase the rate of combustion in the immediate neighborhood of the tuyere, thereby raising the temperature at this point and introducing clinker trouble. Since the highest temperature attained in the fuel bed is usually at or near the point at which the air first enters the fire, it is plain that for uniform low-temperature conditions the grates should have as large surface as possible. This condition can easily be met and the low resistance of the fuel bed next to the lining compensated for by increasing the depth of fuel next to the lining, or by locating the gas outlet centrally in the top of the generator chamber. It is obviously radically wrong to locate the fuel magazine in the center, since this procedure increases the resistance in the center of the fuel bed where it is already high, and makes hard driving and high temperature next to the producer lining inevitable. On account of the low operating temperatures permissible, if clinker troubles are to be avoided, it is necessary not only to adopt very moderate driving rates, but to allow the greatest possible amount of time of contact between blast and fuel by making the active part of the fire very deep. In this way the equilibrium condition for the ratio of $CO$ to $CO_2$ can be more nearly approached, and the disadvantages of low producer temperatures from a gas-making standpoint compensated for in no small degree. On anthracite the rate of driving should not ordinarily exceed 8 pounds per square foot per hour. For bituminous coals the rate may be considerably raised, and on good fuel may even go to twice this figure. The depth of fuel bed in either case should preferably be not less than 5 feet.

A very deep fuel bed has other advantages than simply to contribute to producer efficiency. When the producer is operating under varying loads, and particularly when a suction producer is supplying a gas engine, it must be prepared to meet sudden demands for increase of gas without too much alteration in gas quality. When the producer is operating at light load it is probable that not more than 16 or 18 inches of the fire is engaged in active combustion. However, the fuel lying immediately above this is heated red hot simply by contact with the hot gases passing from the fire below. This red hot fuel is capable of entering into immediate combustion as soon as any air is brought into contact with it. Accordingly, when a sudden load is thrown on the engine, and a correspondingly sudden demand for gas is made, the increased velocity of flow through the fuel bed immediately draws air into the upper layers which, although red hot, have not been chemically active. These upper layers are capable of instantly supporting combustion, and they contribute in this way to maintaining uniform gas quality, and permit the producer to respond to variations in load that could not otherwise be met. The large mass of fuel within the producer has a correspondingly large store of thermal energy, and exerts by its mass a very desirable steadying effect on the whole gas-making process. The producer is accordingly able to carry over sudden demands simply by virtue of heat energy previously stored in the fuel bed, which may be gradually restored later, and thus performs, to some extent, the function of a thermal fly-wheel.

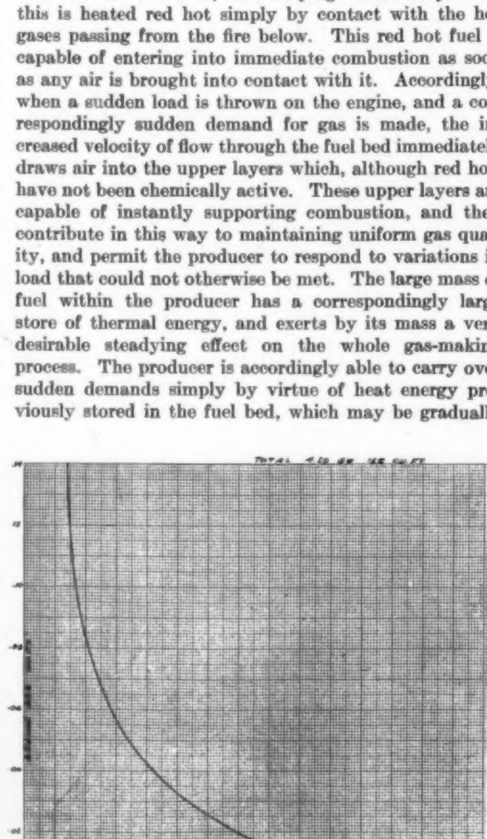


Fig. 11.—Curve Showing Reduction of Tar in Gas.

When we consider the gasification of coals containing volatile matter, another element is introduced which requires most careful attention. Not only does the presence of hydrocarbons affect the method of gasification in the producer by introducing a distillation process which must be carried on at the expense of heat generated in the gasification of the fixed carbon, but the problem of maintaining a uniform gas quality is complicated by the rich hydrocarbons from the destructive distillation of the fuel, and the cleaning of the gas must be carried out with much greater thoroughness. It is in connection with this class of fuels that the most interesting work is being done at the present time in the field of producer design. It is accordingly not inappropriate that the various plans that have been suggested and promoted for the gasification of bituminous fuels should be briefly discussed.

The remarks in this connection relate, of course, almost entirely to the production of gas for power purposes, although the importance of uniform gas quality for furnace work is coming daily into greater prominence. The ordinary type of up-draft producer for bituminous coal cannot possibly produce a uniform grade of gas. Not only are the methods employed for saturating the blast utterly inconsistent with close regulation of the blast quality, but the ordinary method of distilling the volatile matter from the coal is such as to make uniform gas production impossible. The distillation of volatile hydrocarbons from bituminous coal is a process that absorbs considerable heat. It can take place, therefore, only where this heat is being supplied either by combustion in the immediate neighborhood of the fuel being distilled, or by contact with hot gases proceeding from a portion of the fuel bed which is maintained at high temperature. In the ordinary type of fuel producer, the fresh fuel is simply dumped onto the top of the fuel bed and exposed to the hot gases issuing from the burning fuel immediately beneath. When a fresh charge of fuel is dropped, a rapid evolution of hydrocarbon gases results with a corresponding rapid increase in gas value. After the fuel has been exposed to this temperature for some time, the production of volatile gases diminishes, but the coking of the fuel is not complete until the coal has descended into the very hottest region of the fire, since very high temperatures are necessary to drive off the last volatile matter from the coal. To overcome the difficulty from variation in gas quality resulting from sudden distillation of hydrocarbons from the coal, two general methods have been suggested; first, by regulating the rate of distillation of hydrocarbons, and second, by so altering the characteristics of the distilled gases by suitable chemical reactions that they will not differ materially in heating value from the gas resulting from the gasification of fixed carbon. Both of these processes are to some extent successful, and the degree to which each may be successfully applied is a matter of no little interest. The chief argument in favor of the first method, namely, regulating the rate of distillation without altering the characteristics of the distilled gases, lies in the fact that this process permits the use of a very simple type of up-draft producer, and results in the production of gas that is of materially higher heating value per cubic foot than can be produced from fixed carbon alone. These advantages are not to be considered lightly. Simplicity of apparatus is certainly much to be desired, and the production of gas high in heat value has an important bearing on the cost of gas power equipment, since the power that can be developed by an engine of given cylinder displacement depends, to a considerable degree, on the minimum heat value of gas supplied. The cost of equipment, therefore, to satisfactorily accomplish a given work will be materially lower when a gas of high heat value is produced. It has been maintained that more satisfactory results can be secured from low heat value gas, since the engine efficiency can be raised, by increasing the compression, to a point where just as much power can be developed as with a richer gas. While this is undoubtedly true, this increase in power and efficiency is always accompanied by a necessary increase in the strains on the various working parts sufficient to demand heavier construction, or, lacking this, the operation of the plant on a lower factor of safety.

The chief interest that attaches to the various means that have been suggested for altering the chemical character of the distillation products from bituminous fuel, lies in the possiblity of eliminating tar by this process, and thereby simplifying the cleaning plant required. Two methods have been most frequently employed for treating the hydrocarbon vapors to alter their chemical characteristics: First, decomposition by heat; second, combustion with oxygen.

If tar-free gas is to be produced by either of these processes, it is essential that the conditions for chemical alteration of the volatile hydrocarbons must be maintained until the final trace of volatile matter has been driven from the coal. In other words, the coking of the fuel must be absolutely complete before the coke can be considered as fixed carbon and treated differently than

would be permissible for the bituminous fuel from which it is produced. This means that the distillation process whereby the volatile matter is separated from the fixed carbon in the fuel must be unusually thorough. It is interesting to note that ordinary gas-house coke is not by any means sufficiently carbonized to be considered fixed carbon for producer purposes. Likewise, charcoal contains too much bituminous matter to be used in an ordinary up-draft producer without special provision for removing tar from the gas before it is passed to the engine. The process of distillation whereby the volatile matter is driven from the coal must be materially more thorough than that employed in the ordinary bench gas process, or in the production of charcoal, if tar-free gas is to be generated from it. If we assume, however, that this distillation process has been satisfactorily carried out, and the volatile matter completely separated from the fixed carbon, its subsequent treatment demands further consideration. These hydrocarbons can be completely converted into fixed gas and carbon by exposure to a sufficiently high temperature for a sufficient length of time. It would seem, therefore, that all that would be required would be to pass the volatile hydrocarbons, as liberated, through a bed of incandescent fuel, thereby heating them to a high temperature, and bringing about their decomposition into carbon and fixed gas. Unfortunately, while it is relatively easy to bring about a partial decomposition in this way by the use of heat alone, it is not by any means so easy to make the decomposition complete. The tendency of hydrocarbons treated in this manner is to split up into two portions, one of which is a fixed gas and the other a mixture of hydrocarbons more dense than the original body. This process may be continued to its finality, but as each step of the reaction takes place the next requires the use of higher temperatures and longer time of exposure for its completion. If a sufficiently high temperature could be maintained within the fuel bed, and the hydrocarbon gases brought to this high temperature and held there for a sufficient length of time, the production of perfectly tar-free gas from these hydrocarbons could be accomplished. Generally, however, it is found that the temperatures required and the time of contact necessary for such a complete reduction, are both beyond the range permissible in producer practice. We have already seen that we are strictly limited in our producer operations to a temperature that is below the fusing point of the ash contained in the fuel, and with most American fuels this temperature is considerably too low to cause the complete dissociation of the hydrocarbons given off during distillation. Consequently, while a process of treatment of this kind will result in a considerable reduction in the amount of tar, the resultant gas will nevertheless be by no means tar free.

A more ideal method for handling these hydrocarbons would seem to be offered by the process of complete combustion. The hydrocarbon vapors given off by distillation are extremely inflammable. If they are completely burned with air to their elementary products of combustion, namely, $CO_2$ and water vapor, all elements that might possibly contribute to the production of tar or lampblack would be removed. These products of combustion would be very highly heated by their combination with oxygen, and could easily be regenerated into combustible gas by being passed down through the fixed carbon remaining from the destructive distillation. In this way a perfectly clean gas, free from either tar or lamp-black and of uniform chemical composition, and consequently of uniform heat value, could be satisfactorily produced.

Many producers have been designed in an effort to incorporate this principle in a commercial machine. Two fundamental difficulties are encountered which are independent of any question of design, and which have a very material bearing on the success of this type of apparatus. The first of these is the difficulty of securing sufficient completeness in the coking or distillation process. The thorough coking of any fuel containing a considerable quantity of bituminous matter is a process that requires not only high temperature, but considerable time. The fuel is heated from without inward, and time is required for the heat to penetrate to the interior of the lump of coal. This penetration is continually hindered by the current of volatile matter that is passing out toward the surface of the fuel from within. Driving off the last traces of volatile matter requires a very high temperature, and the combined requirements of high temperature and long time of exposure make a difficult problem. Of course the complete distillation of hydrocarbons is absolutely essential in all double-draft machines; that is to say, in machines in which the fixed carbon is gasified up-draft after the manner of the ordinary up-draft producer. It must be assumed, in machines of this type, that nothing but fixed carbon is delivered in the up-draft zone, since any volatiles proceeding from this part of the producer would pass out of the gas outlet unfixed. This process of distillation can be materially hastened and made more complete if a portion of the fixed carbon is consumed during the process of distillation. This not only materially increases the available heat, but by reducing the size of the lumps of fuel by removing carbon from the surface it favors more rapid coking. However, any combustion of fixed carbon increases the second difficulty of which we will now make mention.

It is evident that if complete reduction of the hydrocarbon vapors without formation of either tar or lamp-black is to be attempted, these must be completely burned to their ultimate products of combustion—carbonic acid and water vapor. It is, therefore, pertinent to inquire whether or not there is sufficient fixed carbon in the fuel to reduce the products of combustion arising from the complete burning of the volatile hydrocarbons. In order to bring this matter clearly to mind, the writer has selected four more or less characteristic American coals. The chemical analysis of these fuels is taken from the U. S. Geological Survey report. The first of these is Pocahontas. Chemical analysis of this coal shows a total of 90 per cent carbon, of which 80 per cent is fixed carbon and 10 per cent is combined with 4.6 per cent hydrogen to make a total of 14.6 per cent volatile matter. To completely burn this volatile matter would require for the carbon 27 parts by weight of oxygen to form $CO_2$ and for the hydrogen 37 parts by weight of oxygen to form $H_2O$. These products of combustion to be completely reduced to CO and H would react with 50 parts by weight of fixed carbon. The Pocahontas coal, however, contains 80 parts by weight of fixed carbon so that there would be, with this fuel, an ample supply of fixed carbon to reduce completely the products of combustion of the volatile matter, and with a sufficient margin to cover contingencies and imperfections in the process. Considering, in the same way, a West Virginia coal from the Fairmont District, we have 63 per cent fixed carbon and 28.6 per cent volatile matter. If this volatile matter is completely burned 56 parts by weight of fixed carbon would be required to reduce the products of combustion. This coal contains 63 per cent by weight of fixed carbon, so that we can reasonably expect this process to be practical with coal of this quality *if no fixed carbon is burned during the distillation process.* If we consider, in like manner, a characteristic Illinois coal, we find it to contain 50 per cent fixed carbon and 27 per cent volatile matter. To completely reduce the products of combustion of this volatile matter, 57 per cent of fixed carbon would be required. With this grade of coal, therefore, it would seem to be impossible to carry out this sort of producer process efficiently, even if we assume that the volatile matter could be completely driven from the coal without loss of fixed carbon, and that these volatile products could be completely burned without excess of air. Since neither of these propositions is commercially practical, it is seen to be a physical impossibility to operate a producer on Illinois bituminous coal on this principle. Considering, in the same way, a characteristic Indiana coal, we find the fixed carbon to be 49 per cent, the volatile combustible 31 per cent, and the fixed carbon required to reduce completely the products of combustion resulting from the volatile combustible material to be 61 per cent. There is available in this coal, however, only 49 per cent fixed carbon. It is, therefore, seen that this coal is also impractical for this method of operation. Of the four coals considered, it is plain, if any reasonable allowance is made for the unavoidable imperfections of the process, that only one, namely, the Pocahontas coal, possesses the necessary characteristics to permit this process to be successfully carried out. The great majority of bituminous fuels, available in this country at least, are not amenable to this process of treatment owing to inherent defects in their composition. This process cannot be applied with any prospect of commercial success on fuels containing less than about 75 per cent fixed carbon. When fuels containing less fixed carbon than this are used, the process must be more or less incomplete at one point or another. If the volatiles are completely reduced so that neither tar nor lamp-black are formed, then the producer operation must necessarily be inefficient, since a portion of the products of combustion must pass forward unreduced, and stand as an unavoidable loss in the gasification process. If, however, the combustion of the volatile matter is not complete, that is to say, if insufficient air is supplied to completely burn them, then the production of tar or lamp-black is unavoidable. Neither of these processes is carried out completely in any form of commercial apparatus. The ordinary down-draft producer may be taken as representative of most of the attempts that have been made in this direction. In this the distillation process is materially aided by the combustion of a part of the fixed carbon. The volatile matter is partially burned in contact with an insufficient supply of air, this process resulting in the liberation of lamp-black from the hydrocarbons. Those hydrocarbons that escape combustion, either complete or partial, are to some extent broken up in passing through the incandescent carbon in the lower levels of the producer and converted by heat into fixed gas and tar, or, if the fuel bed temperature be sufficiently high, into fixed gas and coke. No producer yet designed for bituminous fuel has succeeded in producing a gas that is at all times sufficiently clean to make the use of efficient purification unnecessary.

| Coal. | Fixed Carbon. | Volatile. | | Oxygen to burn volatile to $CO_2$ and $H_2O$. | Carbon necessary to reduce $CO_2$ and $H_2O$ from combustion of volatile to CO and H. |
|---|---|---|---|---|---|
| | C | C | H | | |
| Pocahontas... | 80 | 10 | 4.6 | 64 | 38 |
| W. Virginia... | 63 | 23 | 5.6 | 106 | 56 |
| Illinois....... | 50 | 21 | 6.1 | 104 | 57 |
| Indiana...... | 49 | 25 | 6.2 | 116 | 61 |

The materials to be removed from gas in the cleaning process vary with the fuel from which the gas is derived. With blast-furnace gas the impurities to be removed consist almost entirely of inorganic dust arising from the iron ore and limestone fired to the furnace. In gas from anthracite, the principal impurities to be removed, aside from the relatively small amount of fine ash which is carried over, consist almost entirely of sulphur or some compound of sulphur in a finely divided state. The deposit occurring in piping and valves from anthracite producers always contains a large percentage of sulphur, if this substance is found in any considerable quantity in the coal. It is probable that this sulphur dust originates from the spontaneous decomposition of various sulphur compounds in the gas, many of which can undergo chemical changes at ordinary temperatures with the liberation of sulphur dust. Gas from bituminous coal will require purification from tar or lamp-black or both, depending on the processes used in treatment the hydrocarbons in the coal. In connection with the utilization of gas from bituminous coal, the point on which the most serious question is usually raised is on this matter of gas cleanness, and particularly on the complete freedom from tar.

In order that some idea may be gotten of the problem involved in purifying gas from bituminous coal, the writer has recently conducted some investigations that will enable him to present to you a few figures representing, approximately at least, the characteristics of tar in producer-gas. In raw bituminous producer-gas, the tar is carried in the form of minute particles, or, as it is commonly designated, as tar fog. In the particular case investigated by the writer, the gas carried a total of approximately 4 grains of tar per cubic foot. The tar particles were found to vary in size from about 0.00008 to 0.00015 inches in diameter, the average size being in the neighborhood of 0.00010 inches. The number of tar particles was found to be somewhere in the neighborhood of 20,000,000 per cubic inch. These particles are so small and their ratio of surface to mass so great that they are influenced almost entirely by their surface relations with other bodies and very slightly by their mass. The viscosity of the gas is so great that the tar particles move through it very slowly. The surface action predominates to such an extent that it is impossible to separate the tar particles from the gas by centrifugal force alone, even though the difference in density between the gas and tar fog is very great. It might be remarked here that the so-called centrifugal tar extractors do not operate by the action of centrifugal force on the tar particles but in an entirely different manner. These particles are so minute that any ordinary filtering medium will not trap them. The particles will pass freely through the meshes of almost any woven fabric. When passed slowly through as much as ¼ inch of wool felt, the issuing gas still contains a considerable quantity of the tar fog. In view of the smallness, the elusive property and enormous number of these particles, the results that can be attained in cleaning producer-gas with suitable appliances are certainly remarkable. There are a number of systems of cleaning producer-gas that are more than 99 per cent efficient; that is to say, of the 20,000,000 tar particles contained in a cubic inch of raw gas it is comparatively easy to remove 19,800,000 by suitable processes. When the quantity of gas required in a power plant of very moderate dimensions is taken into consideration, the work to be done by a scrubbing plant assumes enormous proportions. A 200 horse-power plant, for example, will use approximately 16,000 cubic feet of gas per hour. In a plant of this size the cleaning apparatus is under the necessity of removing from the gas 140,000,000,000 tar particles per second. No practical method has yet been devised for removing absolutely all of the tar from the gas, but by the use of appliances that need not be at all complicated, it is possible to bring the cleaning plant to a very high degree of effectiveness. It is at present not beyond the range of possibility to produce, in a commercial way, gas containing not more than 0.001 of a grain per cubic foot. This implies a scrubbing efficiency of 99.99 per cent. Gas may be considered sufficiently clean for gas engine use under any ordinary conditions if the impurities are reduced to less than 0.03 of a grain per cubic foot. From this it would seem that the margin between the necessary degree of gas cleanness, and the possible degree of gas cleanness, is distinctly sufficient to constitute an ample factor of safety.

# Aviation To-day*

## And the Importance of a National Aerodynamic Laboratory

By Capt. W. Irving Chambers, U. S. Navy

INFLUENCE OF FOREIGN LABORATORIES.

LITTLE more than a year ago our knowledge of the effect of air currents upon aeroplane surfaces was almost entirely a matter of theory. The exact information available was so meager that aeroplanes were built either as copies, slightly modified, of other machines, or else by way of haphazard experiment. This state of affairs obtains to some extent in the United States to-day, although in Europe aeroplane construction is now largely based on scientific data obtained at notable aerodynamic laboratories.

The intuitive, hasty, and crude methods of the pioneer cannot succeed in competition with the accurate and systematic methods of the scientific engineer, and it is beginning to dawn upon our perceptions that through lack of preparation for the work of the scientific engineer, i. e., through delay in establishing an aerodynamic laboratory, a waste of time and money, a decline of prestige, and an unnecessary sacrifice of human life already resulted.

Students of aviation do not need to be informed of the practical necessity for aerodynamic laboratories. They have repeatedly pointed out, in aeronautical publications, the immense commercial advantages to be anticipated from the establishment of at least one in this country, and they have naturally expected that some philanthropic patriot of wealth and scientific interest would come to the rescue with a suitable endowment fund that would enable such work to be started in short order without Government aid. The fact that no patriot has responded is disappointing in view of the large private donations that have done so much for aviation in France; but, in my opinion, it simply indicates something lacking in the manner of disseminating information concerning the importance of the subject. I am not willing to believe that our people will refuse to establish one when they are fully acquainted with the advantages to humanity and to sane industrial progress, and when a reasonable concrete proposition is advanced for their consideration. I have submitted such a proposition as follows, being guided in general outline by the ideas advanced in an address to the Fifth International Aeronautic Congress by one of the greatest authorities in the world, the Commandant Paul Renard, president of the International Aeronautic Commission.

A NATIONAL AERODYNAMIC LABORATORY.

The work done by Prof. Langley at the Smithsonian Institution, in a brief period, over sixteen years ago, with meager resources and little encouragement, by means of an appropriation under the Chief of Engineers, U. S. Army, was such a valuable contribution to the science of aeronautics that the United States, even to-day, is credited abroad with possessing a real aerodynamic laboratory. I fancy there are people in this country who believe that the work inaugurated by Langley is still proceeding in a systematic way, but it is unfortunate that his work was not permitted to expand and to develop into one of the first national institutions of this kind.

The first of the modern laboratories was that of the French Military Establishment at Chalais, and now the laboratories of the Italian specialist brigade in Rome, the Russian laboratory at Koutchino, and that of M. Eiffel (formerly at the base of the Eiffel Tower and now at Auteuil) are already landmarks in the world of progressive science. It is worthy of note that M. Eiffel's latest discoveries have verified, to a remarkable degree, some of Langley's early work. Such laboratories exist also in England at Bushy Head, and in Germany at Göttingen, and it is well known that M. Henri Deutsch de la Meurthe gave a large sum to the University of Paris, about two years ago, to found a similar establishment at St. Cyr, which has already done valuable work.

In addition to these laboratories, devoted exclusively to aeronautical investigations, there exist in certain industrial establishments engaged in other work certain installations, more or less rudimentary, which permit of aerodynamic experiments.

A distinct revolution has resulted in the methods used to advance the art and science of aeronautics, and in the efforts of technical investigators in this field.

According to Dr. Zahm, who worked with Langley, an ideal aerodynamic laboratory is one "in which a staff of trained specialists, provided with adequate apparatus, shall furnish physical constants, laws, formulas, and empirical data of substantial and permanent value to the engineer, the inventor, the manufacturer, whose energies should remain free to employ such knowledge to the advancement of important industrial arts; a laboratory where complete and reliable tests and reports shall be made upon all classes of actual air craft that may be worthy of study and development; an institution surrounded by ample maneuvering space of land and water, and preferably adjacent to a Governmental flying ground, available with hangars and shops to all civilians worthy of assistance; a center of scientific and practical activity, where at all times may be witnessed the most accurate researches, the most varied exhibitions of air craft, models, and appliances; the most skillful demonstrations; the most exhaustive tests, where expert investigators, constructors, and operators shall mingle freely with amateurs, sportsmen, capitalists, and substantial business men all mutually inspiring and stimulating one another, all animated by the common desire for the early and complete commercial realization of a direct, rapid, and universal system of transportation."

CHARACTER OF THE WORK. THINGS TO AVOID.

Before considering the character of the work to be done, and some details of the needed plant, it will facilitate matters to show what should *not* be done at such a laboratory.

There are those who dream of supplying the laboratory with all the instruments known to mechanics, to physics, and even to chemistry, in order to have a creditable and complete national institution. They would concentrate in one locality all the scientific instruments and acumen available with the false idea that economy would result. This would be a grave error.

The financial resources, however great, are sure to be limited, and a too ambitious or a superfluous installation would squander the sources of power, and indirectly menace the initiative of other industries. The character of the new work to be done demands that everything should be rejected that can be dispensed with readily, in order that appliances specially needed in the new work may be provided, and that these appliances be of the latest and most efficient types.

For the sake of economy, not only of money, but of time and intellectual energy, tests and experiments that can be executed as well or better elsewhere by existing establishments should be avoided. For example, it is unnecessary to install a complete set of instruments and implements for testing the tensile strength of materials or their bending and crushing strength. Many other establishments permit of such work. If the laboratory be located in Washington, where certain advantages exist, such work could be readily done at the navy yard, where other facilities exist, such, for instance, as the testing of models for hydroaeroplanes or flying boats. The Bureau of Standards and Measures, and other Government branches in Washington, also offer facilities which it would not be wise to *duplicate* in such a laboratory.

I do not think that such an institution should be burdened with measuring the power of motors, or preoccupied with the details of their performances. This may be done at various other Government establishments, and it is understood that the Automobile Club of America is also equipped for this work.

Nor is it necessary to have a complete chemical laboratory under the pretext of studying questions relating to the chemistry of fuel, or the permeability of balloon envelopes.

I do not wish to convey the idea that an aerodynamic laboratory should be deprived entirely of such facilities and that it should be obliged to seek minor information from other establishments when that information may be more economically obtained by a duplicate plant on a small scale. Such duplicate conveniences, however, should be regarded as strictly accessory, but it should be well understood that, whenever important researches can be prosecuted as well or better elsewhere, dependence should be placed on those other establishments where such work is a specialty.

TWO DISTINCT CLASSES OF WORK.

An aerodynamic laboratory should be devoted to (1) experimental verification, (2) experimental research. The first is concerned with testing the qualities of existing appliances, propellers, sustaining surfaces, control mechanism, etc. Usually these tests are made at the request of interested parties (as is now the case with water models at the Navy Yard Model Basin). A constructor or a designer will bring, for example, a propeller, and will wish to know its power or thrust at a given speed on the block, or on a moving appliance under the conditions of flight, or he may bring several propellers to compare their performances, and to ascertain what power they absorb at different speeds.

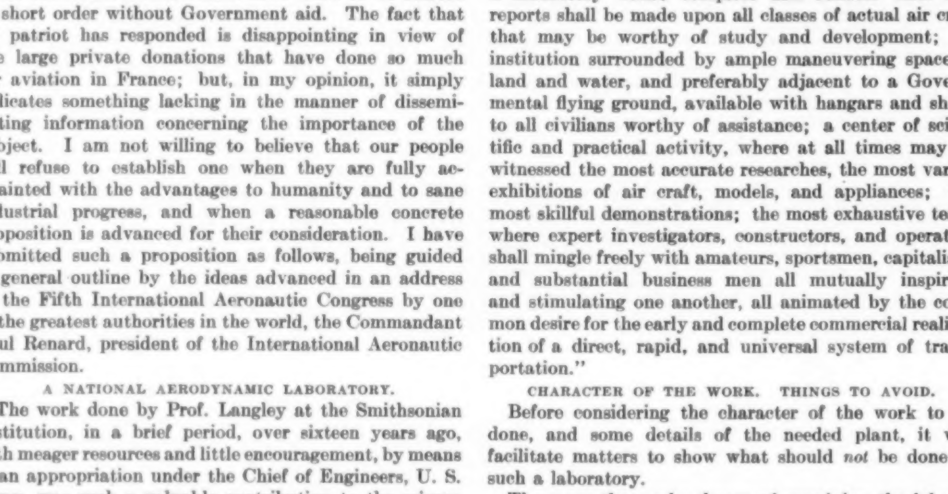
One of the very successful appliances devoted to this work at St. Cyr is a movable car in which an aeroplane may be mounted and tested at speeds, in perfect safety, as to its strength, its efficiency, and the stability of its control mechanism. This device is specially adapted to make actual service tests of sustaining surfaces, in other words, to try out, in perfect safety, the relative efficiencies of finished aeroplanes. It is a most important adjunct, as it supplements and rounds out the important research work on models in the closed laboratory.

Tests of this character, i. e., verification tests, constitute, so to speak, standard work. They are performed at the request of manufacturers, clubs, independent investigators, and other interested parties on condition of payment for the actual cost of the work. They, therefore, contribute to the support of the establishment.

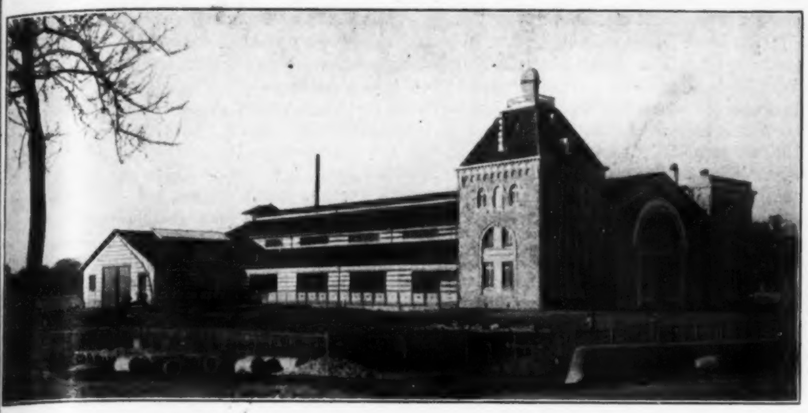
The tests of verification, however, notwithstanding their great utility, do not constitute either the most important or the most interesting work of the laboratory. The *research work*, which prosecutes continuous and patiently systematic, thorough, and precise investigation of new ideas, or of old ideas with new applications, with the specific intention of discovering laws and formulas for advancing the progress of aerial navigation, is of greater importance, because it is the short cut to substantial efficiency, economy, improvement and prestige.

This work is concerned with developing adequate methods of research in all branches of aerial navigation, and in furnishing reliable information to all students, engineers, inventors, manufacturers, pilots, navigators, strategists, and statesmen. The knowledge thus gained should be disseminated regularly through publications, lectures, open-air demonstrations, and by exhibitions

* This article, for which we are indebted to *Flying*, is the substance of a report made to the Navy Department, September 21st, 1912.



The Eiffel Aerodynamic Laboratory at Auteuil, Near Paris.



The St. Cyr Aeronautic Institute—Endowed by Henri Deutsch de la Meurthe.

The Aerodynamic Laboratory of Koutchino, Russia.

apparatus, instruments, materials, and models, in ct, by all the facilities of the aerodrome, the showom, the library, and the lecture room.

An exact knowledge of aerodynamics can best be quired in such a laboratory by experimentation with andard scale models in air tunnels such as those used y M. Eiffel and others. In this way reliable data are btained of the air resistance to be encountered and he efficiency at various velocities, the amount of lift, he effect of varying impact at different angles of attack n the stability, in fact, all the exact data which, reuced to curves and diagrams, enable the engineer to esign a machine in a scientific manner. From such ta the performance of a new machine can be closely redicated. The performance of the finished product an be verified later as before described.

Much of the research work will be prosecuted at he request of technical men outside of the institution o whom the laboratory should offer, gratuitously as r as possible, its material and personal resources.

THE COUNCIL AND ORGANIZATION.

To obtain benefit from these researches it will be ecessary to know that they are worth the time and xpense, and a body of men, a council or a board of overnors, should be authorized to accept or reject reests for this work. This will be a delicate task, but he principal duty of the council should be to establish d to correct, from time to time, a programme of he research work to be executed by the director and s staff, and to co-ordinate the work to the best adantage within the limits of the money available. The sbursement of the Government funds, however, and he responsibility therefor should be entirely under he director.

With the actual state of aerial navigation and its ficiencies as a guide, it will be the policy of the council concentrate effort upon such points as seem most portant, promising and interesting for the time ing.

I do not think there would be any doubt, if we had e laboratory in working order now, but that all estions relating to improvement in stability, automatic ntrol, and safety in general would have the right way.

The council or board, which in England is called the dvisory Committee," should be representative of her Government departments than that employing e director, and should be independent of the director d his administrative staff. It might be possible the director to act as a member of the council, d, if so, it would conduce to harmony and expedition. The council should not be a large body, but should composed mostly of specialists of unquestioned ility, men interested in the sane development of ial navigation in various branches of the Governnt, and in its useful and safe adaptation to comrce and sport.

Whatever the ability of this council, it should not allowed to pretend that it has a monopoly of aerotic acumen. Many brilliant and worthy ideas may ginate outside of the establishment which it will be wise to investigate. And to avoid any possibility of the council being charged with narrow prejudice, it is indispensable that it be not composed entirely of specialists. In a few words, it should comprise representative men who are also learned and technical men, with broad vision and reputation, whose presence will guarantee to industrial investigators that their ideas will be treated in an unpartisan or unbiased spirit. I will not attempt to suggest the composition of this council or board, but it is evident that the army and the navy should each be adequately represented on it.

ENDOWMENTS, PRIZES, AND REWARDS.

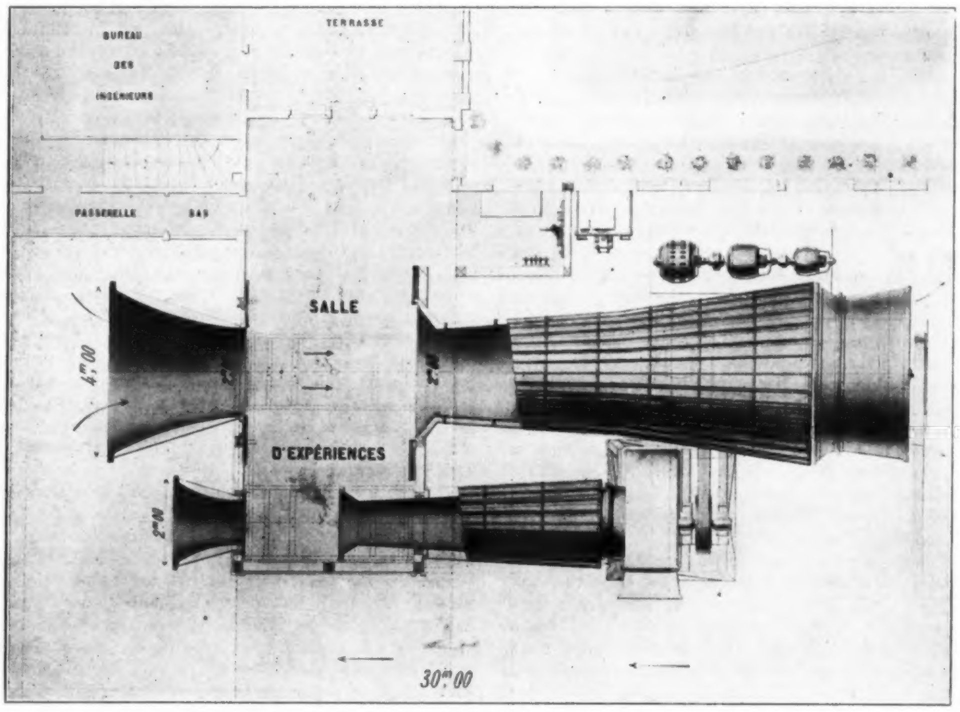
If the laboratory should obtain, in addition to the funds required for prosecuting researches by its staff, any endowments of financial aid in excess of immediate needs (and I am confident it will eventually), it would accomplish useful work by offering prizes and granting rewards for important results achieved outside of the institution. The division of rewards would be one of the functions of the council, and it is possible that this would be one of the best uses of such resources, after the success of the laboratory is assured.

The *complete role* of an ideal aerodynamic laboratory can be summed up now in a few words in the natural order of establishments: (1) Execution of verification tests by means of nominal fees; (2) facilities to technical men for prosecuting original researches, (3) execution of researches in accordance with a programme arranged by the council; and (4) reward of commendable results accomplished outside of the laboratory.

NATURE OF THE PLANT.

Researches and tests can be made on either a large or a small scale, preferably on both.

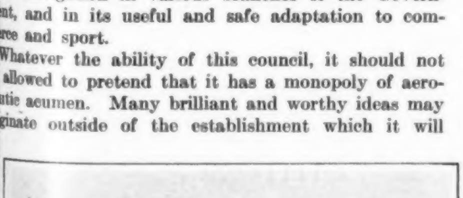
The use of small models can be made prolific in results because of the comparatively small cost, provided we understand the laws governing transformation into the full-sized products. For model work a large plant is unnecessary. M. Eiffel has done very valuable work in a very small establishment.



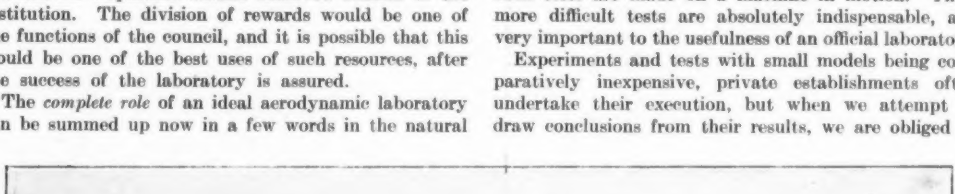

Plan of the New Aerodynamic Laboratory, the Large and Small Wind Tunnels.

Certain classes of tests with large models, such, for example, as the block test of propellers, do not require much space. But the conditions are altered when such tests are made on a machine in motion. These more difficult tests are absolutely indispensable, and very important to the usefulness of an official laboratory.

Experiments and tests with small models being comparatively inexpensive, private establishments often undertake their execution, but when we attempt to draw conclusions from their results, we are obliged to



he Latest Curtis Flying Boat, With Glen H. Curtiss and Capt. W. I. Chambers at the Helm.



Partial View of the Military Aeroplane Review at Villacoublay, France, in Which Seventy-two Aeroplanes Took Part.

admit that the laws of comparison with full sized machines are debatable the world over. Comparisons are sensibly true between small surfaces and larger surfaces that have been extended proportionately to the square of the linear dimensions, even to surfaces five or ten times larger, but when we pass to much larger surfaces, as we are obliged to, we are forced to adopt formulas with empirical coefficients about which there is indefinite dispute.

The difficulty can be overcome only by precise experiments upon large surfaces, and such experiments, whatever the manner in which they are performed, will be costly. If privately executed the financial returns would not cover the cost.

The laboratory should comprise, therefore, two distinct parts, one devoted to experiments on small scale models, and the other to experiments on surfaces of large dimensions. But in both parts precise and thorough work is necessary.

When we have studied separately each element, of an aeroplane, for example, it will be necessary to test the complete apparatus. An aerodrome annex is therefore necessary, or, at least, the laboratory should be located in proximity to an aerodrome of which it can make use. In order that the observations may not only be qualitative but quantitative, it will be necessary to follow all the movements of the complete machine, to know at each instant the speed, the inclination, the thrust of the propellers, the effective horse-power, and, in fact, to conduct a true open-air laboratory for the craft after the manner of certain tests that have been prolific of results in France.

The English have established close relations between the Royal Air Craft Factory and their laboratory, the functions of the former being the reconstruction and repair of aeroplanes, the test of motors, and the instruction of mechanics.

LOCATION OF THE LABORATORY.

The location of the model testing plant, the headquarters of the administration staff, requires comparatively small space, and there is no reason why it should be remote from a city or from intellectual and material resources. It is advantageous to have it easy of access to many interested people who are not attached to it.

The location of the open-air laboratory should obviously be at an aerodrome, as near as may be convenient to the model-testing plant or headquarters. Close proximity of the two parts is desirable, but not necessary. The high price of land near a large city obliges the aerodrome annex of foreign plants to be located at a distance, but we are fortunate in having here, at Washington, ideal conditions for the location of both parts. The model laboratory should obviously be located on the site of Langley's notable work at the Smithsonian Institution, where the nucleus, an extensive library of records and a certain collection of instruments, are still available. The National Museum is also an ideal location for the historical collection of models that will result.

No more ideal location for the annex, the open-air laboratory or aerodrome, exists in all the world than that afforded by the, as yet undeveloped, extension of Potomac Park. This is Government property which is of doubtful utility as a park only, but which would be of immense utility and interest as a park combined with a scientific plant of the character under consideration.

There is no reason why the public should be excluded from such a practice field, but there is much to recommend that it be open to the public under proper regulations as to the traffic, especially on occasions of certain tests or flights of an educational value. It is of sufficient area, about one square mile. It is about two miles long, and it is almost entirely surrounded by broad expanses of water. While convenient of access, it is so situated that the public may be readily excluded when tests of a dangerous character are in process of execution. The fine driveways that will be required as a park will offer excellent facilities for the practice work of the aerodrome, and for the moving test cars that should be supplied.

One of the most attractive features of this location is the advantage it offers as an ideal aerodrome for both the army and the navy, for both land and water flying, and the opportunity it affords for co-operation in all branches of the work of instruction and experimentation. Furthermore, it is near to the shop facilities of the Navy Yard, the accommodations of the Washington Barracks, the conveniences of the various Government hospitals, and it would doubtless add to the information and interest of the nearby War College Staff, and the General Board of the Navy. This location would enable our statesmen in Congress, and a great number of officials in all departments, to keep in touch at first hand with the progress of aeronautics, with the quality of the work done, and with the manner in which the money appropriated was being expended. The educational facilities afforded by the work and by the lectures would be invaluable to the course of instruction for army, navy, and civil students of aeronautics.

As Washington is a Mecca for business people of all parts of the country, a laboratory located here would be convenient in a commercial sense, especially in view of its southerly location, which renders the open aerodrome available for use throughout the greater part of the year. The only objection that I can see to the Potomac Park extension is that the ground will require a considerable clearing. It is now, principally, a vast cornfield.

THE APPARATUS NEEDED.

It is useless to discuss here the various instruments and methods which have been a source of some dispute abroad. All have some good feature, but time has shown where some of the cumbersome and unnecessary installations may be eliminated to advantage, and where others may be improved. The new plant of M. Eiffel at Auteuil may be regarded as a model for the wind tunnel and the aerodynamic balance. A duplicate of that plant alone would be of inestimable value. The last volume published by M. Eiffel is a forcible example of the value of his discoveries, by this method, with respect to the angle of incidence, and the displacements of the center of pressure. It seems to merit the utmost confidence, although the details of his installation differ from those at Chalais, at Koutchino, at the Italian laboratory, and others. This method permits of testing the resistance of body structures, the sustaining power of surfaces, the tractive power of propellers, and the influence of transverse or oblique currents. If a "free drop" apparatus at uniform speed be regarded as indispensable to obtaining the coefficients of air resistance to solid bodies of different shapes, it is possible that the interior of the Washington Monument could be used to advantage, as was the Eiffel Tower, without disturbance of the main function of that noble structure. This would be an excellent place from which to observe the stability or action of falling models cast adrift at an altitude of 500 feet under varying atmospheric conditions. The free drop of full-sized models would, of course, require the use of kites or captive balloons.

The moving car previously referred to for tests of verification would be the most useful open-air plant, and would soon repay the outlay required by the value of the information obtained from its use. A miniature duplicate of this method for preliminary tests on models with a wire trolley would be of value in a hall of large dimensions. It would be useful in winter work, but not invaluable.

The track of the open-air vehicle at St. Cyr is too restricted to give the best results. The car cannot circulate continuously at high speed and maintain the speed for a sufficient length of time. An ideal endless track may readily be arranged at the Potomac Park extension, preferably of rectangular form with rounded corners. A railway track would be preferable, but excellent results could be obtained from auto trucks run on macadamized roadbeds. Good results could be obtained by the use of suitable hydroaeroplanes or flying boats suitably equipped with instruments.

Whirling tables are useful only when designed of large radius. They belong necessarily to the open-air plant, but unless considerable expense is sacrificed for installation they can serve for reduced models only. I would not recommend their installation until the necessity for their use is clearly demonstrated.

At the aerodrome annex ample facilities should be provided for measuring the wind velocity at various heights and at different points. The convenient installation of recording anemometers, and the employment of kites or captive balloons should be considered.

A branch of the U. S. Weather Bureau could readily be established at the aerodrome here in connection with the investigation of meteorological phenomena affecting the movements of aeroplanes in flight, and as an adjunct to the National Laboratory.

Exactly measured bases and posts of observation are also required, as well as instruments of vision or photographic apparatus, to permit of following machines in their flights, and of preserving the records for study.

One of the most useful installations for recording advanced information is in an actual aeroplane itself equipped with instruments adapted to record, while in flight, much of the information that is desired. Such a machine is already in use in France, and in England.

It will be in perfect harmony, and convenient to the laboratory, to obtain all the services of an air-craft factory from the Washington Navy Yard, where facilities already exist for the reconstruction and repair of aeroplanes, the test of motors, and the instruction of mechanics. But this should not be allowed to interfere with our policy of relying upon private industry for the purchase of new machines for the sake of encouraging the art among private builders.

It will suffice to merely mention the hangars or sheds required, or the local accessories, such as drafting room, office, and minor repair shop. The character and location of these present no difficulties, but they should not be made the principal part of the institution as they are in several elaborately equipped foreign laboratories. The power plant, however, is a subject for careful consideration, and the economy effected by M. Eiffel in his new installation at Auteuil is worthy of study.

COST.

I have seen estimates varying from $250,000 to $500,000 for such a plant, but inasmuch as $100,000 with an annuity of $3,000 donated by M. Henri Deutsch de la Meurthe to the University of Paris for the establishment of the Aeronautical Laboratory at St. Cyr seems to have been sufficient for a very creditable though somewhat deficient plant, I will venture an opinion that $200,000 would be sufficient in our case. Although the same plant would cost more in this country, I assume that some of the buildings required are already available at the Smithsonian Institution. If located elsewhere the cost would be considerably more than the sum named.

A COMMISSION RECOMMENDED.

Inasmuch as more definite information regarding the actual cost of a dignified and creditable but modest and sufficient installation should be obtained, and as the details of the plan, the scope, the organization, and the location of such an important undertaking should not be left to the recommendations of one man, a commission or board should be appointed to consider and report to the President, for recommendation to Congress, on the necessity or desirability for the establishment of a national aerodynamic laboratory, and on its scope, its organization, the most suitable location for it, and the cost of its installation.

It is hoped that the preceding outline is sufficiently definite to start the machinery of legislation necessary to expedite the acquirement of such an institution. The plant is needed not only to further the interests of science and national preparedness, but to further the interests of humanity. By such means we can best hasten the production of safety and efficiency in air craft, and reduce our percentage of martyrs in aviation, which is now greater here than in any other country. Aviation has come to stay, and I believe popular sentiment is in favor of making it safe.

# The Government and Our National Timber

## A Defense of the Present Policy

SELLING NATIONAL FOREST TIMBER.

THE crucial test of public ownership and management of forests in the United States will be the power to resist an unintelligent demand for the Government to sell timber cheap, on the supposition that this will enable the public to buy lumber cheap.

WOULD IT PAY?

The Government is now being criticised for not selling National forest timber cheaper and faster. It is charged with virtually aiding private timber monopolies to gouge the public. In point of fact it is doing just the reverse.

The Government could not materially lower the cost of lumber to the average consumer if it were to reduce by half the price charged for timber cut on the National forests. But it could enable many lumbermen to grow rich fast. Also, it could and would prepare the way for a timber monopoly later that would be a monopoly with a vengeance. Incidentally, it would promote wanton and great waste of valuable timber, both on and off the National forests, by operators who would merely skim the cream, and it would permit the extra cost of bad management to be saddled on the public.

HOW TIMBER IS SOLD.

The average price at which National forest timber was sold on the stump by the Government last year was $2 per thousand.

The Forest Service spent thousands of dollars advertising its timber. It seeks purchasers by every means in its power. It sold last year the equivalent of about 800 million board feet of timber in all forms—for lumber, mine props, fuel, posts, and many other uses.

The cut, for lumber alone, of the entire United States was between 40 and 45 billion feet.

All sales of over $100 worth of timber were made after advertisement for competitive bids. The Forest Service is prohibited by law from selling in any other way. It is also prohibited by law from selling or offering for sale any timber until after it has been appraised, or for less than the appraised value.

To permit of timber being sold for less than its market value, the law would have to be changed.

Should it be changed?

THE CONSUMER PAYS THE MARKET PRICE.

Who would have benefited if the timber actually sold last year had been sold at half the market price, or given away?

Would the general market price have been less to the purchaser from the retail dealer? Not one cent. The manufacturers who cut this insignificant fraction of the country's total lumber cut would have sold their lumber at the market price, pocketing the $1 or $2 or $3 per thousand less than the market price of stumpage with which the Government had presented them. But if they had sold to the wholesaler for less, would he have handed the present on to the retailer? And if the retailer had got any part of it, would he have given it to consumers?

To enable the consumer to benefit by a stumpage price less than purchasers of stumpage stand ready to pay, the Government would have to manufacture, transport, and market the lumber, selling directly to the consumer from its own retail lumber yards.

TO MATERIALLY LOWER THE RETAIL PRICE BY INCREASING THE CUT THE GOVERNMENT WOULD HAVE TO OVERCUT ITS FORESTS.

But suppose the Government had, by giving timber away to all applicants, raised the National forest cut to one fifth of the entire cut of the country.

In point of fact, it could not have done this by giving the timber away. It would have had to pay lumbermen to come and get it. With lumber prices where they are now the Government can get from 50 cents to $5 per thousand for its stumpage, under competitive bids, the price depending on the location and kind of timber sold. Ten years ago it could not have given away what it is selling to-day. Not, that is, as stumpage. It could easily have given the timber to speculators to hold for rising prices.

The present National forest stand forms one fifth of the country's total supply of saw timber. If one fifth of the annual lumber cut were drawn from the forests and at the same time they continued to supply the timber in other forms demanded by western mining, agriculture, and other industries, the forests would be cut off faster than the country's total supply.

The country's total supply is being cut three times as fast as it grows.

If the Government gave timber away and the consumer got the full benefit, the $2 per thousand gain to him would be but a trifling part of the retail price. It would not restore the cheap lumber prices of a few years ago.

SALES OF GOVERNMENT TIMBER FOR LESS THAN ITS MARKET VALUE WOULD DIRECTLY PROMOTE MONOPOLISTIC CONTROL OF TIMBER SUPPLIES.

Years before the National forests were set aside speculators were busy securing the best timberlands of the public domain. Twice as much Western timber is in private as in public ownership.

At any given price level, there is a certain amount of timber that will pay the cost of cutting. The rest is not on the market because to cut and manufacture it would cost more than it would sell for.

Privately owned timber involves carrying charges to the owners—interest on capital tied up, taxes, and cost of protection or fire risk. Private owners are therefore under pressure to sell and extinguish these charges. They also have, as a rule, the timber that would naturally be first to come into demand. They saw to that when they got it.

But, at a given price level, there is always a limit to the amount of timber that is on the market. The owner will not go beyond a certain point. When that point is reached he prefers to hold, not manufacture, his timber.

After lumber prices fell in 1907 many lumber mills operated at a loss rather than shut down altogether. The owners had miscalculated the demand, but having set up their mills could not shut down altogether without incurring greater losses than those involved in running. The output in 1912 in the West was only about 60 per cent of the capacity of the mills.

This is what the lumber trade know as "over-production."

The consumer thinks there is not production enough, because lumber costs him more than it did ten years ago. But the forests that supplied him ten years ago are gone. Though there is still plenty of timber left, it is less accessible and more expensive to get on the market.

If the Government cuts its stumpage price in half, more mills will be located on the forests, *but fewer will operate outside*. The cut from Government land will take the place of part of the cut from private holdings. In effect, the Government would pay a bounty to induce operators to cut its trees instead of their own.

Part of this bounty would be a pure gift to the operators. Men who find it to their advantage to buy National Forest timber at the present prices would make more money. To the extent that the cut from Government land took the place of the cut from private holdings, the bounty would represent the cost of bringing about this substitution. It would be the inducement held out to secure the reversal of the order dictated by business conditions.

This would inevitably accentuate the condition known to the lumber trade as "over-production."

Those operators who are now breaking even or running at a loss or with curtailed output would of course, *if they could*, withdraw from the market and let the cut from Government lands take the place of the cut from their holdings.

If they could all do this, the consumer would not be benefited at all. But not all could. They have incurred business obligations which they must meet. The weak ones would be shaken out. The value of stumpage would decline. The strong ones would seize the opportunity to add to their holdings. The field for speculative buying of timberlands would be wide open again.

Gradually a condition of equilibrium would be restored. The surplus of stumpage artificially created would be absorbed, partly by cutting, partly by speculative acquisition and withdrawal. Private timber would be concentrated in fewer hands. Public timber would have diminished. The chance for monopoly profits and artificial control of the market would have been made materially greater. Then the consumer would pay the score—with usury.

POLICY OF THE FOREST SERVICE.

The Forest Service is selling timber as fast as this can be done without sacrificing the interests of the public. It is making every effort consistent with sound business to dispose of the over-ripe stumpage on the forests and bring the annual cut up to a fair portion of the yield. It is advertising commercial opportunities on the forests widely and successfully. Its sale contracts are framed to meet practical business and logging conditions. They are accepted by business men and are attracting large investments. The small manufacturer is sought wherever he is equipped to utilize the timber. But where the capital and organization of the big operator are needed to develop inaccessible areas, large sales are made. Yet in all contracts, holding timber for speculation is prohibited and the payment of the proper value is assured by frequent adjustments of price.

This policy is succeeding. The use of National Forest timber on a sound and stable basis is increasing rapidly. Within twelve months over 1½ billion feet has been sold. Many operators are looking to the forests for new locations. If the demand is sustained, the yearly sales will soon reach 3 billion feet. The annual growth on a number of forests which are within reach of markets is now fully used. As transportation facilities are extended, this will be brought about on every forest.

## The Origin of Planets and Their Satellites*

In a recent issue of the *Comptes Rendus*, Prof. K. Birkeland brings forward a novel theory, based upon experiments and mathematical theory, of the origin of the Solar System.

"Guided by experimental analogies," he says, "I have been led to believe that there are, in solar systems in the course of evolution, certain forces of electro-magnetic origin which are of the same order of magnitude as gravitational forces, and that these forces, acting together, have given rise to planets revolving round the sun in nearly circular orbits, situated in nearly the same plane, to moons and rings round planets, and to nebulæ in the shape of rings and spirals." The farthest moons of Jupiter and Saturn, with their retrograde motions, do not invalidate this conception; and if an ultra-Neptunian planet is ever discovered, it ought to have a retrograde motion round the sun.

Birkeland's fundamental assumption is that all stars have an enormous negative electric potential, different for different stars, but amounting to some 600 million volts in our sun and in stars of the Solar type. He shows by "experimental analogies" how a magnetic field may form round the star, with its axis in the axis of rotation, and how electric discharges may be produced by preference round the magnetic equator, accompanied by a continual projection of electrified material particles, which continue to move in the same plane.

A mathematical investigation shows that, under the combined action of electric, magnetic, and gravitational forces, while most of the particles will fall back upon the sun, a large number will gradually approach limiting circles, whose radii depend upon the ratio of the charge on the particle to its mass. Those having the highest electric charge will form the outermost circles. If the magnetization of the sun is reversed north and south, as compared with that of the earth, the negative particles will have a retrograde motion, and larger asymptotic circles, whereas positive particles will have a direct motion.

Those particles which reach the limiting circle can continue to move in it for all time. But probably they will combine to form larger globules as their charges are lost.

If a particle loses its charge abruptly, it will describe an ellipse round the sun, with its perihelium in the limiting circle, and with an eccentricity the smaller, the greater its distance from the sun.

Prof. Birkeland claims to have proved that the metal projected by the disintegration of a cathode consists largely of positively charged metallic particles, and he prints a photograph of the discharge from a globular magnetized cathode in an exhausted vessel of 320 liters capacity, which shows an appearance much resembling the Zodiacal Light round the sun, in the shape of a flat, glowing, circular plane, with the magnetic axis at right angles on its center.

He suggests that the changes in a cathode closely resemble radioactive changes, and that the emission of particles may be accompanied by heat, as in the case of radium. This suggests a new source for the heat of the sun.

Since all stars must, on this view, project particles, it would follow that most of the matter in space must be sparsely disseminated, instead of being aggregated into large masses.

If all the matter in the Solar System were evenly distributed in a sphere whose radius is the distance of the nearest star ($\alpha$ Centauri), there would only be one atom in every cubic centimeter of space. Even if there were 100 times that amount of matter, it would probably not be discoverable by any known method of observation.

* Reproduced from *English Mechanic and World of Science.*

## Radiations in Economics

When we consider the many important processes in the arts and industries which depend upon the action of ferments the suggestion that these may be replaced by mere physical agencies is bound to claim attention. There are now some observers in the ever-expanding field of electrical study who are beginning to assign to the silent electric discharge, or to the ultra-violet rays thereby produced, a power to hydrolyse substances capable of undergoing that process. Starch at any rate after some hours' exposure to the silent discharge gradually resolves into sugar. It is well known, of course, that acids will do the same thing, and for a long time sugar has been prepared from starch by boiling it with acids. That was the first step which made the brewing and distilling industries independent if need be of the use of diastase as a converting agent. The mash tun can thus be replaced to some extent by the converter.

The acid used as the hydrolytic agent must, of course, be removed, but, if it should prove that by the mere exposure of starch to the silent electric discharge it can be converted into sugar on a commercial scale, it is possible that both ferment and acid may at some future time be dispensed with. Further, according to M. D. Berthelot, the hydrolytic action of ultra-violet rays is not confined to carbohydrates, for albuminoids have been converted into soluble proteins by exposure to the rays, the action of pepsin and other enzymes being thus imitated. There can be little doubt that the study of the action of ultra-violet rays, or of the silent discharge, is leading to interesting developments which may possess great practical importance. The application of ultra-violet rays to the sterilization of water-supplies furnishes an example, although it appears probable that there is still room for improvements in this application in order to make the process a completely efficient one. The extension of this principle to the preservation of both liquid and solid foods is also foreshadowed, although here considerable difficulty is encountered owing to the opaqueness of the materials to the radiations. Of exactly in what way the sterilization is effected we do not appear to have received a satisfying explanation, some attributing it to the action of ozone and others to a direct killing property of the rays. A process of preserving perishable foods, independent of the use of chemicals, about the innocence of which there is doubt, would obviously be a valuable discovery to the community. The continued researches on these questions will be looked forward to with the greatest interest.—*The Lancet.*

# Correspondence

*[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]*

## Determinism vs. Free Will

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

In the issue of October 12th, 1912, of the SCIENTIFIC AMERICAN, I note, under the above caption, the views of a Mr. Stimson in favor of Determinism. With your kind indulgence I desire to add a few remarks from the opposite viewpoint.

It is true, as Mr. Stinson says, that it is often difficult to distinguish between our experience and that which theory or inference has established as the truth. This is due to the fact that our daily thoughts and acts are so largely occupied with our physical environment, with which science is principally concerned, that we confound the data of consciousness derived therefrom with those which arise from the inner or psychical life. We are prone to objectify the subjective states of consciousness and to assign to them attributes of magnitude and duration, and our habit of thought in dealing scientifically with externalities in terms of space and duration leads us insensibly to represent our psychical facts similarly, and our reasoning upon operations of the mind thus becomes illusionary.

Science has arrived at some generalizations, such as the Persistance of Force, Conservation of Energy, and Universality of Causation, with a high degree of certainty. But it is to be noted, right here, that the causality of the objective world is merely *universal sequence*, when considered philosophically.

Metaphysics leads us to see that the only really causal entity in the universe is mind. The material world is phenomenal and consists of a vast or infinite congeries of sequences, not causally related in the profound sense in which the effect is necessarily included in the alleged cause.

When Mr. Stinson says "people act in the same way under the same circumstances," if he means by circumstances the environment of the individual, he is obviously wrong. And, on the other hand, if he means by circumstances the sum total of the individual's experience, it will be recognized at once that it is impossible for any two persons to have had identical histories of experience, for one's experience includes both the conscious and subconscious, of the present, and the hereditary experience of the race.

Character, which forms the basis for choice of action, is this sum total of experience. The mind is actuated in its choice by the character behind it, and not solely by the immediate circumstances, either as environment or as conscious psychical states. If it were not so, all virtue and heroism would be mere mockery. Mr. Stinson says "we expect no heroism from one who has not 'got it in him.'" But how under the doctrine of Determinism has the hero "got it in him?" If he acts merely as he is compelled to act by "circumstances," his heroism is an empty and cowardly act.

Determinism, practically little better than Fatalism, is a dangerous doctrine, both for the individual and for society. It makes man an automaton, and with its close kin, Materialism, leads logically to the denial of mind as a real entity, and to Agnosticism, which is confessed absolute ignorance.

It abrogates the existence of any self-causing or determining power, including the Creator. By Determinism all evolution and advancement are based on the preposterous proposition that a mechanical system is capable of advancing to something higher than itself—of rising above its source.

It is to be admitted that argument alone is incompetent to refute absolutely the doctrine of Determinism, because of difficulties which space will not now permit of even indicating. But each individual who has attained a degree of philosophical culture sufficient to rise above the thraldom of the objective terminology of physical science, may thereby fortify the intuition of the ego, and recognize himself as a free and self-determining arbiter within certain limits.

Not only is Determinism unsatisfactory to the higher intelligence, aside from moral responsibility, and the indubitable conscious facts of experience, but the doctrine of Free Will is more scientific.

To illustrate: As the scientist finds action between bodies at a distance without an intervening medium inconceivable, he assumes a universal ether and endows it theoretically with the properties necessary to explain this action. Science is helpless to explain such phenomena as radiation without this assumption. Likewise science confesses inability to explain the origin and progress of the material universe. But, by assuming a Creator with infinite intelligence, the entire march of evolution is seen to be reasonable, and evolution is recognized as the *method*, not the *cause* of the present world. Man, as the image of his Creator, and therefore having creative power through intelligent choice, within the limits of his finiteness, is the principal factor in the present state of evolution.

We believe, then, that "political, commercial, and financial systems are [not] evidences for Determinism," but rather the product of intelligent choice.

Washington, D. C. W. H. HOWARD.

[The Editor can publish no further letters on this subject.]

## The Lateral Stability of Aeroplanes

### By Prof. Herbert Chatley

THE question of "asymmetric" or "lateral, directional, and rotative" stability of aeroplanes has not yet been satisfactorily settled by either designers or theoreticians. The volitional use of ailerons or warping, with a rudder, has enabled a moderate measure of stability and safety to be obtained, and both Bryan and Lanchester have pointed out many of the fundamental difficulties of designing a machine with inherent asymmetric stability.

Mechanical control of two kinds has been suggested, by (1) gyrostatic wheels or pendula, and (2) the "Sotinel" device of interconnecting the ailerons with the wing mountings in such a way that when the wings can't (relative to the body) the ailerons move so that the reactions on them tend to correct the displacement. All such methods as these (as Bryan has now made clear) are liable to difficulties in connection with accelerations and inertia.

An aeroplane is liable to three distinct movements involving this kind of stability:

1. "Side-slipping," "Skidding" or lateral motion (in a straight line).
2. "Change of course" or rotation in azimuth (not geographical azimuth, but only in reference to the line of flight).
3. "Rolling" or rotation about the longitudinal axis.

These three are inter-connected in such an elaborate manner that no simple conclusions as to the action of a steering surface of any kind can be directly arrived at.

Whenever a machine with straight wings becomes inclined, a horizontal component appears in the thrust and the whole mass tends to slide sideways approximately in the plane of the wings.

When turning through a curve this effect is useful as it provides a means of balancing the centrifugal force, but this adjustment has to be deliberately and accurately made. The process is known as "banking" and the following complications enter into it:

1. The lift becomes less than the weight of the machine, so that unless the elevator is operated it will commence to descend.
2. Unless the banking angle is just right, the machine will skid inwards or outward.
3. Owing to the difference in the speeds of the two wings, the outer wing is lifted more than the inner one and the banking tends to increase.

In the "Sotinel" machine the ailerons will not correct this last matter as the whole car will tend to hang obliquely by reason of its centrifugal acceleration.

Next, as to fins. Any surface whose center of pressure is behind the wings tends to correct for "change of course," but causes side slip. Thus, if a machine is going north and swings to the northeast, a fin behind turns to the west. The resistance against it stops the swing, but causes a side slip toward the east, so that the final path is a little to the northeast.

A high fin corrects side slip, but when there is a change of course and consequent differential wing velocity the high fin aggravates the cant. A low fin has just the reverse effect.

The primary effects of fins can be classified as follows:

| Position. | Change of Course. | Side Slip. | Roll. |
|---|---|---|---|
| 1. Front, central... | increases | damps | slightly damps |
| 2. Rear, central.... | decreases | damps | slightly damps |
| 3. Front, high..... | increases | decreases | damps |
| 4. Front, low ..... | increases | increases | damps |
| 5. Rear, high ..... | decreases | decreases | damps |
| 6. Rear, low ..... | decreases | increases | damps |

It is clear that many designers have not looked beyond these primary effects, trusting to the skill of the pilot to do anything more than may be necessary.

Position No. 4 is obviously to be avoided, and No. 1 looks undesirable. This leaves Nos. 2, 3, 5 and 6. No. 5 is, of course, generally preferred, but like the rest fails to correct for roll. Apparently no single fin can directly deal with this motion.

The principal secondary effects are as follows:

1. Roll due to differential wing velocity following change of course.
2. Side slip due to a fin reaction.
3. Change of course due to side slip.
4. Side slip due to roll.

These various interactions succeed one another, increasing or decreasing the displacements according to their amounts and directions. Without the aid of the "dynamical canon" it seems impossible for the mind to clearly grasp what will eventually happen in any one case, no matter how simple it may appear at first sight. Even experiment with models is not very promising since to convert the results to apply to a full-sized machnie obscure scale relations may be required.

We are finally reduced to the position of

1. Leaving the discovery of inherent lateral stability to chance, trusting at present in the skill and nerve of the pilots.
2. Experimenting endlessly on a large and small scale with fins, dihedrals, keels, plan forms, warped wings, etc., until some fortuitously happy combination partially solves the problem.
3. Following out an elaborate mathematical investigation, checked at every point, with special experimental determinations of every doubtful coefficient, and practical tests of each conclusion arrived at.

The last seems the only rational course, provided the *analytical net is wide enough*. Bryan and his disciples, Soreau, See, Prandtl, and Crocco, put forward a fair claim to possess ability to solve the problem if sufficient encouragement is given them.

Lateral stability and landing are the two outstanding problems of aviation. Efficiency, speed, carrying capacity, even cost, are all unimportant compared with safety.



SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, FEBRUARY 22, 1913

Published weekly by Munn & Co., Inc., Charles Allen Munn, President
Frederick Converse Beach, Secretary and Treasurer;
all at 361 Broadway, New York

Entered at the Post Office of New York, N. Y., as Second Class Matter


**The Scientfic American Publications**

Scientific American Supplement (established 1876). . per year $5.00
Scientific American (established 1845) . . . . . . . " 3.00
American Homes and Gardens . . . . . . . . . . " 3.00

The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.

Remit by postal or express money order, bank draft or check

**Munn & Co., Inc., 361 Broadway, New York**

***The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.***

## Table of Contents